Vol. 17. Parts 4–6. Pp. 35–69. 15th June, 1942

THE PROCEEDINGS
OF THE
ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Series A.
GENERAL ENTOMOLOGY

World List abbreviation: *Proc. R. ent. Soc. Lond.* (A)

CONTENTS

PAGE

BEIRNE, Bryan P., Ph.D., F.R.E.S., F.L.S. Observations on the life-history of *Praon volucre* Haliday (Hym.: BRACONIDAE), a parasite of the Mealy Plum Aphis (*Hyalopterus arundinis* Fab.) . . 42–47, 19 figs.

CARPENTER, Professor G. D. Hale, M.B.E., D.M., F.R.E.S. Note on the bionomics of the Sphegid wasp *Dasyproctus bipunctatus* Lepeletier (Hym.) 48

ELLIS, H. Willoughby, M.I.E.E., F.R.E.S., F.Z.S. John Sang's original drawings of British Coleoptera and Lepidoptera, with a note on Dr. P. B. Mason's collections 62–63

FRASER, Lt.-Col. F. C., I.M.S. Retd., F.R.E.S. A note on the evolution of some venational structures in the dragonfly wing . . 64–69, 2 figs.

HENRY, G. M., F.R.E.S. Three remarkable stridulatory mechanisms in ACRIDIDAE (Orthoptera) . . . . . . 59–62, 2 figs.

MILLER, N. C. E., F.R.E.S., F.Z.S. On the structure of the legs in REDUVIIDAE (Rhynchota) . . . . 49–58, 1 fig.

REID, J. A., B.Sc., A.R.C.S., F.R.E.S. A note on *Leptinus testaceus* Müller (Coleoptera: LEPTINIDAE) . . . . 35–37, 2 figs.

THORPE, W. H., Sc.D., F.R.E.S. Observations on *Stomoxys ochrosoma* Speiser (Diptera MUSCIDAE) as an associate of army ants (DORYLINAE) in East Africa 38–41

BOOK NOTICE 37

LONDON:

PUBLISHED BY THE SOCIETY AND

SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 12s. 0d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1942–1943.

A NOTE ON *LEPTINUS TESTACEUS* MÜLLER (COLEOPTERA: LEPTINIDAE)

By J. A. Reid, B.Sc., A.R.C.S., F.R.E.S.

Whilst digging up a nest of the wild mouse, *Apodemus sylvaticus* (L.), in a flower-bed at Gerrards Cross, Bucks (23.iv.1939), a number of specimens of the curious blind beetle, *Leptinus testaceus* Müller, was found running about rapidly in the material of the nest. A considerable number of very active white larvae was also present in the nest, and these were later kindly identified for me by Dr. van Emden at the British Museum (Natural History) as the larvae of *L. testaceus*. Subsequently one or two adults were bred from the larvae.

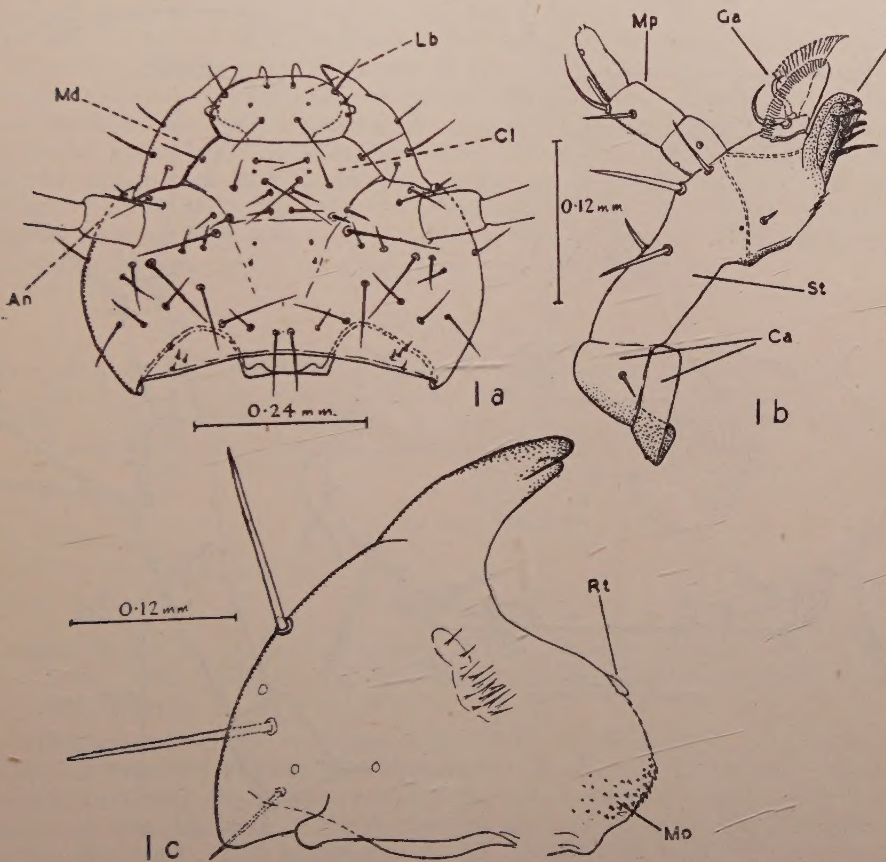


Fig. 1.—(A) Head of the larva of *Leptinus testaceus* Müll. dorsal view. An, antenna; Cl, clypeus; Lb, labrum; Md, mandible. (B) Right maxilla, ventral view. Ca, cardo; Ga, galea; La, lacinia; Mp, maxillary palp; St, stipes. (C) Right mandible, ventral view. Mo, molar area; Rt, retinaculum.

Böving and Craighead (1931) give figures of the larva of *L. testaceus*, but the opportunity is here taken to illustrate the head and mouth-parts of the larva in greater detail.

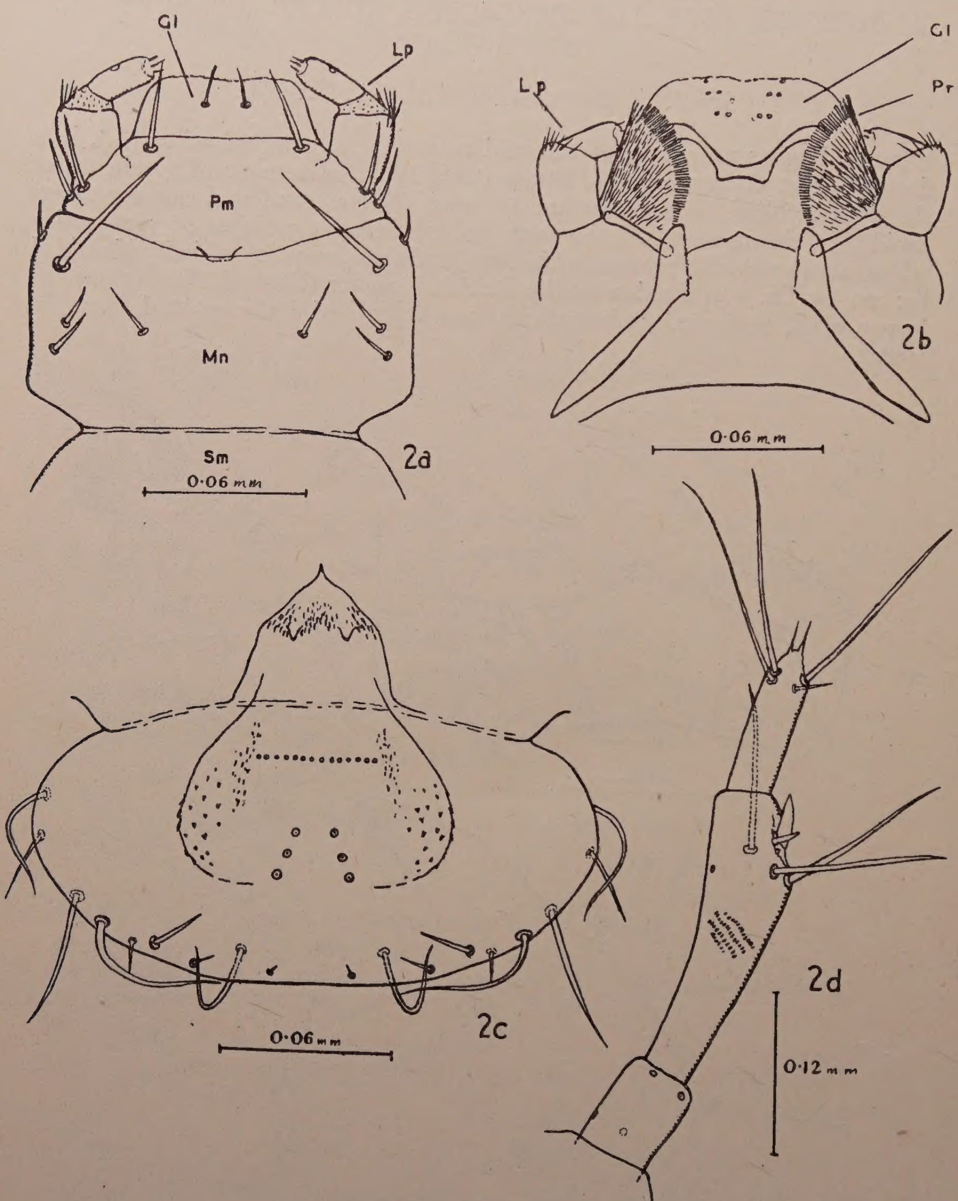


Fig. 2.—(A) Labium, ventral view. Gl, glossa; Lp, labial palp; Mn, mentum; Pm, prementum; Sm, submentum. (B) Labium, dorsal view. Gl, glossa; Lp, labial palp; Pr, paraglossa. (C) Labrum, ventral (buccal) surface. (D) Right antenna, ventral view.

Leptinus testaceus, together with a few allied forms, is held to be related to the curious beetle, *Platypsyllus castoris*, that is found upon beavers. Little is known of the biology of *L. testaceus*, except that it is probably an ectoparasite of wild mice in whose nests it has been found, but it has also been recorded from other situations. Elton and others (1931 : 710) found the species in small numbers on *Apodemus sylvaticus* and *Evotomys glareolus* trapped in Bagley Wood, Oxford, during the years 1925 to 1928. Through the kindness of Mr. Elton I have been able to examine specimens obtained between May 1925 and April 1927, at present in the keeping of Dr. O. W. Richards, whom I wish to thank. When the dates of capture are plotted by months, irrespective of the year, the following frequency distribution is obtained :—

Month . .	1	2	3	4	5	6	7	8	9	10	11	12
No. of beetles .	14	7	3	2	10	4	0	0	16	14	3	20

Examination of the chart of trapping given by Elton shows that this distribution is not merely a reflection of the number of nights trapped or, apparently, of the number of traps put out in different months, and it suggests (though much more data would be required to confirm it) that there are three generations a year with peak emergences of adults in May, September and December. Adults certainly emerge in May, for the specimens bred from the larvae collected on 23.iv.1939 emerged about 12th May. The pupal period in one specimen observed occupied approximately 12 days at 20° C. It is possible that the adults found on 23.iv.1939 were all of the generation parental to the larvae, for another nest of *Apodemus sylvaticus* was found about a fortnight later a few feet away from the site of the original one, and though numerous larvae were found in this nest, no adult beetles were seen. Both nests contained living mice at the time they were opened.

References.

Böving, A. G., and Craighead, F. C., 1931, An illustrated synopsis of the principal larval forms of the order Coleoptera. *Bull. Brooklyn ent. Soc.* **11**.

Elton, C., Ford, E. B., Baker, J. R., 1931, The health and parasites of a wild mouse population. *Proc. zool. Soc. Lond.* **1931 :** 657–721, 15 figs.

Book Notice.

Insetos do Brasil. 2. Tomo. Capítulo XXII. Hemípteros. By A. Da Costa Lima. 8vo. Rio de Janeiro (Escola Nacional de Agronomia), 1940. Sér. Didática 3. pp. 351, 227 figs.

This second volume of Professor Da Costa Lima's work on the Insects of Brazil is restricted to the Order Hemiptera. It opens with a general description of the Order, the external and internal anatomy, habits, economic importance and classification. A key to the families is given and a list of references to the literature. This is followed by the detailed treatment of each family and genus and of the more interesting and important species. Very many of the species dealt with are illustrated. Especially detailed treatment is given to the Triatominae, and other economically important families. The work is very clearly printed in large type.

OBSERVATIONS ON *STOMOXYS OCHROSOMA* SPEISER (DIPTERA MUSCIDAE) AS AN ASSOCIATE OF ARMY ANTS (DORYLINAE) IN EAST AFRICA

By W. H. Thorpe, Sc.D., F.R.E.S.

(*Sub-Dept. of Entomology, Zoological Laboratory, Cambridge.*)

It was my good fortune during the first half of 1939 to make a prolonged stay at the East African Agricultural Research Station, Amani, which is situated at an altitude of 3000 ft. in the E. Usambara Mts., Tanganyika Territory. Although the main object of the visit was an investigation of the parasites of certain Coccidae, a little time was spared for other observations, the habits of the Army or " Safari " ants (Dorylinae) proving particularly interesting. On many occasions while watching the foraging columns of " Siafu " (*Anomma nigricans* Illiger var. *molestus*) I was fascinated by the skill and precision of the marauding Muscid *Bengalia depressa* (Walker) whose habit of snatching their prey from the jaws of the foraging army ant workers has been described by many entomologists. But one evening (23rd Feb. 1939) while on the look-out for *Bengalia*, my wife and I observed a very different fly, yellowish-brown in colour, hovering motionless about one inch above a column of workers of *A. nigricans* which were on their return journey to the " nest," many of them carrying booty. As we watched, a creamy white object, which may have been a very large egg but looked more like a larva, was extruded from the abdomen. Judging by comparison with the size of the fly's abdomen this object was about 2 mm. long and 1 mm. broad. The fly held or steadied the object with its legs for a few seconds and then dropped it into the column, apparently aiming it with great care and precision exactly in front of one of the rapidly marching workers which happened to be returning without booty. Without a moment's hesitation, in fact almost without checking its stride, the worker picked up the white object thus proffered like manna from above and continuing its homeward march disappeared from view a few inches farther on where the track left the bare earth of the footpath to run beneath a cover of grass stems and soil. The fly was then caught by a downward jab of the net which unavoidably trapped also a number of the army ants themselves. Before the fly could be transferred to a separate collecting box it was attacked by two of the *Anomma* which soon inflicted mortal injuries and by the time the laboratory was reached the insect was moribund. Before death, however, the fly extruded one egg from its oviduct; this egg although of a fair size was smaller than the object previously dropped upon the column of safari ants. Owing to the difficulty created by netted *Anomma* this egg was unfortunately lost.

The dead fly was then mounted; although mutilated, its injuries were not sufficient to hinder identification. Judge of my astonishment to find on examination that the specimen appeared to belong to the genus *Stomoxys*; but means were lacking there and then to go any further with the identification. This tantalising glimpse of a most unexpected life-history spurred us during the remainder of our stay in Africa to search for further specimens, but the species was never encountered again.

On return to England the specimen was submitted to Dr. J. Smart of the British Museum (Natural History) and Dr. F. Van Emden of the Imperial Institute of Entomology, who identified it as *Stomoxys ochrosoma* Speiser (= *S.*

flavida Malloch). This species was described by Speiser in 1910 from two females collected on Mount Kilimandjaro by the Sjöstedt Kilimandjaro–Meru Expedition. In Speiser's account the following particulars are given: "2 ♀♀ vom Kilimandjaro, das eine vom 29 September aus der Steppe, das andere vom 19 Mai aus der Kulturzone bei Kibonoto, *merkwürdigerweise beide mit dem nahezu gleichlautenden Vermerk, sie flögen nach Art von Schwebfliegen über Wanderameisen.*" (italics mine). Dr. Van Emden tells me that neither he nor any one else of whom he has enquired knows of any other record of association with ants for this or any other species of STOMOXYDINAE. The species appears to be a rare one and such references as there are in the literature throw little light on the habits of the insect. The Harvard African Expedition (Bequaert) met with one male at an altitude of 4000 feet biting a buffalo and one female biting a mule (south of Lake Kivu, altitude 5000 feet), both in the Belgian Congo, and as a result of these observations Bequaert doubts the reliability of Sjöstedt's record of association with columns of driver ants. The species was also collected by the British Museum Ruwenzori Expedition 1934–5 at altitudes of 4500 feet and 6500 feet in the Ruwenzori massif itself and also in the Budongo Forest. It is also known from Kampala, Uganda, at 3750 ft. and from Nairobi, Kenya, at 5500 ft. (see Van Emden 1939), but no observations on habits are given for any of these records. *S. flavida*, which is probably a synonym, was described from Uganda, and *luteola*, which according to Van Emden differs only by its orange interfrontals, was described by Villeneuve from "une seule ♀ de l'Afrique équatoriale et probablement du Congo."

Stomoxys ochrosoma belongs to the most highly specialised group of the genus, having R_1 setulose and the front tarsi of the male with curled outstanding hairs on the proximal segments, and it would perhaps be not altogether surprising if members of this group were found to have a more specialised biology. As Dr. Van Emden has pointed out to me, the occurrence of larviparous habits in *Stomoxys* would, if confirmed, be an interesting point with regard to the disputed question of the relationship between the STOMOXYDINAE and *Glossina*. *Stomoxys calcitrans* is the only member of the genus whose breeding biology has so far been investigated. It is oviparous, laying two, or very occasionally three, batches of anything from 50 to 120 eggs, each about 1 millimetre long (Bishopp, 1913). With a view to obtaining further light on the reproductive habits of the genus the remaining eggs were extracted from my one specimen of *ochrosoma*; they proved considerably smaller than the object which the fly had dropped into the ant column. Also female specimens of a number of related species, namely *pallida* Roubaud, *omega* Newstead, *neavei* Malloch, *brunnipes* Grünberg, *nigra* Macquart and *wigglesworthi* Zumpt, were examined and were compared with *calcitrans*. This was rendered possible by the courtesy of the authorities of the British Museum (Natural History), the Imperial Institute of Entomology, the London School of Hygiene and Tropical Medicine, the Hope Department of Oxford University and the Liverpool School of Tropical Medicine. These dried specimens were examined by removing the abdomen, treating for some days in cold $\frac{1}{2}$–1% KOH and then dissecting. By this means egg shells can easily be extracted from the oviducts and it was felt that if any of the specimens contained larvae the mouth-parts and spiracles at least would be clearly visible. The results of this investigation have, however, proved disappointing. A large proportion of the specimens available had either already laid all their eggs or were newly emerged with the ovaries as yet undeveloped, and in no case has any clear evidence of larviparous habit been found. But there is evidence of an interesting difference in size and number of eggs which is shown in the table

below and which may be significant. The flies are all approximately the same size.

Species	Length of adult fly	Dimensions of " Ovarian " eggs		Approximate number of eggs
		Length	Breadth	
S. calcitrans L.	7·0 mm.	1·0 mm.	0·35 mm.	50–120 (two or even three batches)[1] *Total* approx. 100–250
S. ochrosoma Speiser	7·0 mm.	1·2 mm.	0·40 mm.	25
S. pallida Roubel	5·5–6·0 mm.	1·0 mm.	0·35 mm.	75–80
S. neavei Malloch	6·0 mm.	0·85 mm.	0·25 mm.	75–80
S. nigra Macquart	6·0–7·0 mm.	1·25 mm.	0·30 mm.	60

This suggests that while *ochrosoma* is at least ovoviviparous, even closely allied members of the genus have simple oviparous habits similar to those of *calcitrans*.

Here then the evidence ends for the present. It is known that the fly sucks the blood of mammals like its congeners; it appears that its ovaries produce a smaller number of larger eggs than is the case with its near relatives; we know that it is either viviparous or ovoviviparous and that it drops its offspring into the marching columns of army ants to be picked up by foraging workers; but the rest is conjecture. From the rather variable scavenging habits of *calcitrans* in the tropics one would imagine that the larva of *ochrosoma* is more likely to be a scavenger in the bivouacs of the army ants than a predator on the ants themselves; but even so there must be some very delicate quality possessed by the egg or larva, which prevents it being devoured or injured by the worker ants without rendering it too distasteful to be carried by the foragers. And what of the adaptations shown by the adult itself? That she herself is not distasteful seems clear from the way in which the specimen was vigorously attacked in the net and by the fact that it is necessary to drop the egg or larva from the air. The great precision of the process suggests that the female aims at a particular worker and that she can distinguish between workers returning empty-handed and those carrying booty. Can she also distinguish an outgoing from a returning column? Or would an outgoing worker, suddenly presented with this strange booty from above, turn round and return to the bivouac forthwith depositing it in safety? Whatever the truth, the fact that a small number of large eggs is produced suggests that wastage is trivial. Among other Muscoid groups (*e.g.* Calliphorinae, Rhiniinae) a number of instances of association with Doryline and other ants and with Termites are known but in no single case has the full life-cycle yet been unravelled. It appears, however, that in these instances the association is much less elaborate than that shown by *S. ochrosoma*. Perhaps the case most closely similar is that of *Tricyclea* (*Zonochroa*) *semithoracica* Villeneuve, which, according to the observations of Farquharson and Lamborn (*in* Lamborn 1914), drops its eggs into the entrances of temporary nests of *Dorylus*. But in this case, instead of ensuring that the egg is received by an ant, the fly seems to avoid the ants and prefers

[1] These figures for *S. calcitrans* are based on the observations of Bishopp in the U.S.A. The records of Newstead (*in* Newstead, R., Dutton, J. E., and Todd, J. L., 1907, *Ann. trop. Med. Parasit.* **1** : 80) and of R. C. Muirhead Thomson (1937, *Parasitology* **29** : 289) suggest that in Great Britain the number is slightly lower. I have not been able to find any figures for tropical African conditions.

those entrance funnels which for the time being are not frequented. This genus appears to be fungivorous in the larval stages but the species evidently have widely differing modes of life (see Engel and Cuthbertson, 1937). These and many other fascinating problems of behaviour await the worker who has the opportunity and temerity to make a systematic investigation of the " nests " of the Dorylines.

In conclusion I wish to express my gratitude to Dr. Van Emden for help in identification, in providing material and in drawing my attention to some interesting records. Mr. H. Donisthorpe very kindly identified the ant. For the loan of material I am much indebted to Prof. Hale Carpenter, Prof. R. M. Gordon, Dr. J. Smart and Dr. V. B. Wigglesworth, F.R.S.

Summary.

Stomoxys ochrosoma Speiser hovers motionless about 1 inch above the marching columns of the army ant *Anomma nigricans* var. *molestus*, dropping its large eggs, or possibly its newly hatched larvae, singly with great precision in front of workers returning without booty. The egg was seen to be immediately carried off in the direction of the nest by the worker which received it. Further details of the life-history are unknown except that the fly has been recorded as feeding on the blood of mammals, as do its congeners. An examination of the abdominal contents of females of this and of a number of closely related species of the genus, points to the conclusion that *S. ochrosoma* is ovoviviparous and that it lays a smaller number of larger eggs than do its nearest relatives. The "ovarian" egg of *S. ochrosoma* measures 1·2 by 0·40 mm., but before extrusion increases to approximately double this size. In *S. calcitrans* there is no such increase.

References.

Bequaert, J., 1930, Harvard–African Expedition : *Report upon the African Republic of Liberia and the Belgian Congo.* Section XXXVI : 797–1001, " Medical and Economic Entomology."

Bishopp, F. C., 1913, " The Stable Fly (*Stomoxys calcitrans* L.), an Important Live Stock Pest." *J. econ. Ent.* **6** : 112–126.

Engel, E. O., and Cuthbertson, A., 1937, " On the Biology of some Rhodesian Diptera, together with descriptions of three new species of Asilidae new to science." *Trans. Rhodesia sci. Ass.* **35** : 1–15.

Lamborn, W. A., 1914, " Further notes on the Driver Ants (Dorylus) of Southern Nigeria." *Proc. ent. Soc. Lond.* **1914** : v–viii.

Malloch, J. R., 1932, " Exotic Muscaridae (Diptera)—XXXVI." *Ann. Mag. nat. Hist.* (10) **9** : 377–405.

Patton, W. S., 1933, " Studies on the Higher Diptera of Medical and Veterinary Importance. . . . II. The Genus *Stomoxys* Geoffroy (sens. lat.)." *Ann. trop. Med. Parasit.* **27** : 501–537.

Speiser, P., *in* Sjöstedt, 1910, *Wissenschaftliche Ergebnisse der Schwedischen zoologischen Expedition nach dem Kilimandjaro, dem Meru und dem Umgebenden Massaisteppen Deutsch-Ostafrikas* 1905–6. **10.** Diptera Cyclorrhapha : 113–202.

Van Emden, F., 1939, *British Museum* (*Natural History*) *Ruwenzori Expedition* (1934–5) *Reports.* **2** : 49–89, " Muscidae : Muscinae and Stomoxydinae."

Villeneuve, J., 1921, " Descriptions de six Tachinides nouveaux d'Afrique." *Trans. ent. Soc. Lond.* **1921** : 518–523.

——, 1934, " A propos de quelques Stomoxys africains." *Rev. zool. bot. Afr.* **24** : 292–293.

OBSERVATIONS ON THE LIFE-HISTORY OF *PRAON VOLUCRE* HALIDAY (HYM.: BRACONIDAE), A PARASITE OF THE MEALY PLUM APHIS (*HYALOPTERUS ARUNDINIS* FAB.)

By Bryan P. Beirne, Ph.D., F.R.E.S., F.L.S.

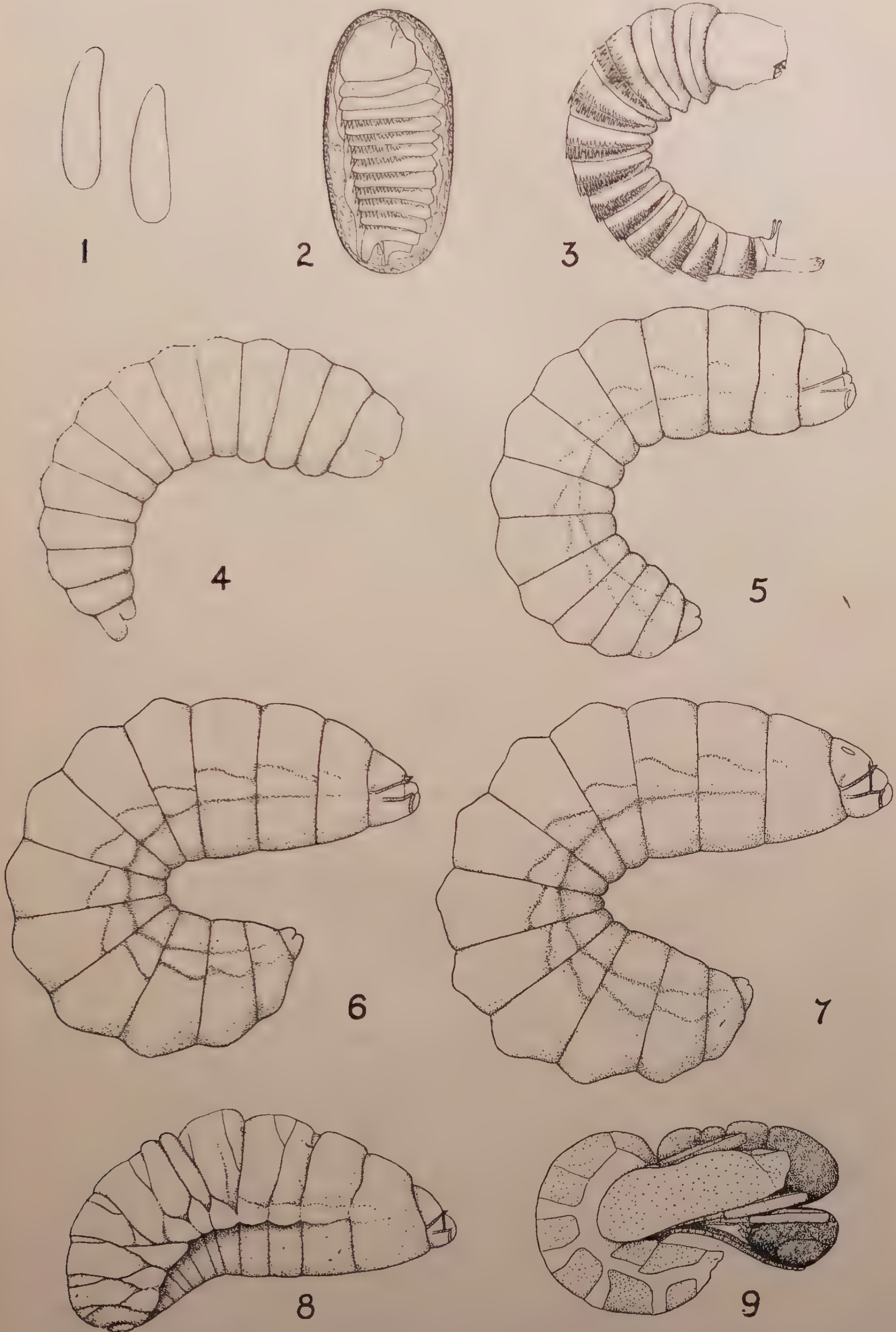
The Mealy Plum Aphis, *Hyalopterus arundinis* F., is an important pest on plum. In Ireland it is attacked by a Braconid parasite which was identified by Mr. A. W. Stelfox, of the National Museum, Dublin, as *Praon volucre* Haliday (Marshall 1899). Adults which emerged from collected parasite cocoons were placed in a jar with some of the Aphides on which they were observed to lay their eggs. Subsequently by dissection of the Aphides the different stages of the life-history were found.

The adult Braconids may be found flying around and resting upon the foliage of plum during the day, but oviposition seems to take place most frequently during the morning. When about to oviposit the female approaches an Aphis and, bringing its abdomen forwards between its legs and underneath its head and thorax, rapidly stings the Aphis (see Clausen 1940, fig. 10); the parasites were frequently observed holding the Aphides in position with their front legs while ovipositing. Usually the parasite approaches the Aphis from behind and deposits its egg between the segments of the abdomen, but the eggs may be laid on almost any part of the body; they are laid indiscriminately on any instar of the Aphis and two or more eggs may be laid in the same Aphis by the same or different females, but each female apparently does not lay more than a single egg in any Aphis at one time, although it may return to the same Aphis later. The females will also attempt to oviposit on anything on the plum leaves which resembles an Aphis in size or shape. Newly emerged parasites were frequently observed apparently feeding on the waxy secretion produced by the Aphides.

Of 291 parasite cocoons collected on plum leaves during the end of July and the beginning of August 77% produced adult *Praon* of which 53% were females and 47% males; 10% of the cocoons produced a chalcid hyperparasite and 7% a cynipid hyperparasite while nothing emerged from the remaining cocoons (6%). Neither hyperparasite was identified. The larvae of both were found feeding as ectoparasites on the *Praon* larvae or pupae in the cocoons, and it would seem likely that the eggs are deposited on the adult *Praon* larvae after they have left the Aphides but before they have formed their cocoons. *P. volucre* was the only species of Aphidiinae which I bred from *H. arundinis* and it was also found parasitising the Leaf Curling Plum Aphis (*Anuraphis padi* L.). According to Marshall (1899) *P. volucre* has been bred from Aphides attacking a number of other plants besides plum.

The egg (fig. 1) is without apparent sculpturing, tapers somewhat at one end and is slightly curved on its long axis. As it develops the egg increases enormously in size, the developing embryo, surrounded by the large-celled trophic membrane, being visible within it (fig. 2). It hatches 3–5 days after it is laid.

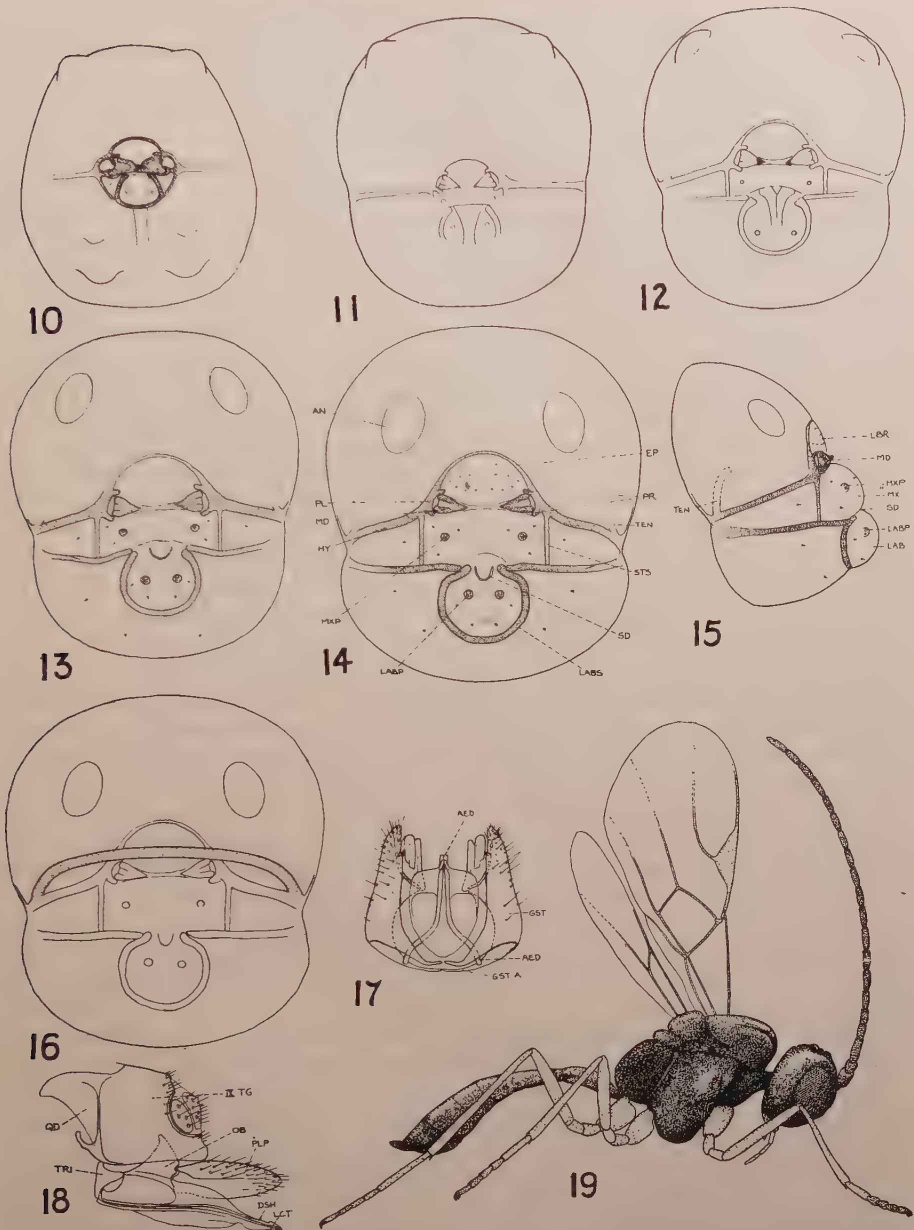
The first instar larva (fig. 3) has thirteen segments in addition to the head, the segmental divisions being well marked. The body tapers posteriorly and the larva is less than 1 mm. long but because of its curvature is difficult to measure accurately. It may be found in the body cavity of the host and more



FIGS. 1–9.—*Praon volucre.* 1. Newly laid ova; 2. fully developed ovum; 3–7. first to fifth instar larvae; 8. prepupa; 9. Pupa. (Figures not to scale.)

than one larva may live in a single Aphis, the greatest number found by me being five, in addition to three ova, while a number of Aphides contained two or three. The first instar apparently lasts four or five days. The head is rather elongated and bears two pairs of ventral papillae, the posterior pair being larger than the anterior pair, which are often not readily visible. The mouth-parts and facial rods (fig. 10) are well developed and are rather different in form from the facial rods of larvae of later instars. The epistomal arch, pleurostoma and pleurostomal rami, the stipital and the labial scleromes and the mandibles are well sclerotised and pigmented, but the hypostoma are not pigmented and only feebly sclerotised, while the maxillary scleromes are not visible; the mandibles are large and powerful, overlapping at their tips, and for their support the pleurostomal rami are each developed as a forked arm. The labial and maxillary palps are barely visible as small rounded areas and the antennae are represented by a pair of rounded prominences dorsal to the facial rods; no facial setae are visible. The three thoracic segments each bear a pair of ventral papillae similar to, but rather larger than, the papillae on the head. A fold or ridge is visible extending around the middle of the first two thoracic segments, while on the third thoracic and all the abdominal segments except the last there is a serrated comb in this position. This comb is made up of a number of posteriorly-directed, flattened spines which are fused to each other at their bases where they arise from the skin. While many of these spines are tapering and pointed, some are wedge-shaped, with a straight or serrated apical edge, while others are Y-shaped or forked, also frequently with wedge-shaped or serrated apical edges. Beneath the skin each of these spines is produced anteriorly as a tapering " root," the length of the root being proportional to the size of the spine. The spines are largest on the dorsal side of the larva, but decrease in size laterally and are absent from the ventral surface. The last body segment, the tenth abdominal, is produced as a long, stout, strongly sclerotised caudal appendage which bears a number of spines at its apex. Ventral to this, and at right angles to it, there is a pair of slender, but well-sclerotised, arms, each arising from a broader base and slightly knobbed and toothed at its apex. The anus opens between the bases of these two pairs of arms and the base of the caudal appendage. A similar type of first instar larva has been noted in a few other Aphidiinae (Timberlake 1910, Wheeler 1923, Janiszewska 1933) and the one other species of *Praon* of which the first instar larva has been studied, *P. simulans* Provancher (Timberlake 1910), is very like *P. volucre* in structure, the spined comb being absent from the first two thoracic segments and the caudal appendage being spined only at its apex.

The second instar (fig. 4) apparently lasts about 3–5 days. Aphides containing larvae of this and following instars may be distinguished by their yellower colour and stouter appearance, which increase as the parasite larvae grow older. Few developing Aphis ova were found in specimens containing parasite larvae of this instar and none in specimens containing larvae of later instars. While a considerable number of Aphides were found to contain two or more first instar larvae, very few contained two second instar larvae and none more than a single larva of later instars, so it would seem likely that in cases of epiparasitism it is at this stage that the best-developed or strongest larvae destroy or cause the death of the others. The head in the second instar larva is much blunter than in the previous or any of the following instars, and is nearly as wide as the thoracic segments. The facial rods and mouth-parts (fig. 11) are not pigmented and are only feebly sclerotised but resemble the larvae of later instars rather than the larva of the first instar. The epistomal



FIGS. 10–19.—*Praon volucre.* 10–14. Head from the front, showing facial rods and mouth-parts, of first to fifth instar larvae; 15. head of fifth instar larva from the side; 16. head of fifth instar larva from behind, showing tentorium; 17. male genitalia, ventral view; 18. plates of ovipositor, lateral view; 19. adult female. (Figures not to scale.) AED: aedeagus; AN: antenna; DSH: dorsal sheath; EP: epistomal arch; GST: gonostipes; GSTA: gonostipital arm; HY: hypostoma; LAB: labium: LABP: labial palp; LABS: labial sclerome; LBR: labrum; LCT: lancet; MD: mandible; MX: maxilla; MXP: maxillary palp; OB: oblong plate; PL: pleurostoma; PLP: palpus; PR: pleurostomal rami; QD: quadrate plate; SD: silk duct; STS: stipital sclerome; TEN: tentorium; TG: tergum; TRI: triangular plate.

arch, pleurostoma and pleurostomal rami, the mandibles, which are small and do not meet at their tips, the hypostoma and the lateral arms of the labial sclerome can be distinguished, as well as a straight tentorial bar extending across the head cavity from the posterior ends of the hypostoma. The antennae are represented by a pair of dorsal prominences but there are no ventral papillae on the head and the ventral papillae on the thoracic segments are very much reduced. The folds and serrated combs are absent from the body segments, but a few small, scattered spines are visible dorsally on the third thoracic and the abdominal segments. The caudal appendage is still present and spined at its apex but is much reduced in length; the paired caudal arms are not present at this stage.

The third instar larva (fig. 5) has completely lost the integumentary spines and caudal processes, the head is more pointed and relatively smaller than in the second instar and the body, which is strongly curved, tapers anteriorly as well as posteriorly. The facial rods and mouth-parts (fig. 12) are all sclerotised but, except for the tips of the mandibles, unpigmented. The epistomal arch, pleurostoma and pleurostomal rami, the mandibles and hypostoma and the stipital, maxillary and labial scleromes are all visible, as well as the labial and maxillary palps, an arched tentorial strut extending across the head cavity from the ends of the hypostoma, and the ovoid antennal areas. The ventral thoracic papillae have disappeared, but slight lateral folds are visible on the body segments. The terminal segment is reduced to a pair of fleshy lobes between which the anus is situated. This instar apparently only lasts for a day or so.

The fourth instar larva (fig. 6) is similar to the third except that the head and caudal segment are more reduced in size in comparison with the body segments; the lateral folds are more pronounced and each abdominal segment is bluntly pointed dorsally, as compared with the thoracic segments which are rounded. The facial rods and mouth-parts (fig. 13) are similar in form to those of the third instar but, except for the epistomal arch and stipital scleromes, are all pigmented. Facial setae are apparent at this stage. When the larva reaches this instar it usually causes the death of the host Aphis and as a result of its consuming the decaying parts of the Aphis the alimentary tract of the larva, which in previous instars is greenish or greyish, becomes dark brown in this and the following instars and so the larva becomes visible through the integument of the Aphis.

The fifth instar larva (fig. 7) is similar to the fourth except that the head and, more particularly, the caudal segment are even more reduced in size in comparison with the body segments. The dorsal prominences on the abdominal segments and the lateral folds are more prominent and the facial rods and mouth-parts (figs. 14, 15) and the tentorium (fig. 16) are all pigmented. A tracheal system was observed in all instars except the first and in the fifth instar spiracles are present on the second thoracic and the first eight abdominal segments. The spiracles are very small, but with a long closing apparatus. In the fourth and fifth instars the integument is closely covered with small prominences but no setae were observed except on the head. At this stage the larva completely consumes the contents of the body of the Aphis and then cuts a hole in its ventral surface and emerges on the leaf where it spins its cocoon. The cocoon is of the form typical of the genus, consisting of an ovoid inner cocoon surrounded by a tent-like outer cover with the empty skin of the Aphis on top. When the cocoon has been formed the body of the larva contracts and becomes divided into three regions, the head, the thorax which is made up of the three

thoracic and the first abdominal segments of the larva, and the abdomen. Owing to the contraction of the body the segmental divisions and the lateral folds become prominent and further folds appear in the integument. At this stage the larva is known as the prepupa (fig. 8). The fifth instar larval stage lasts about a week, of which the greater part is spent in the cocoon.

The pupa (fig. 9) is whitish when first formed but later the head, thorax and antennae become dark blackish-brown, the legs and wings yellowish and the sclerites of the abdomen, which is strongly curved, yellowish-brown. The adult emerges after about a week or ten days so that the whole life-cycle takes less than a month. The pupa is apparently not orientated in any particular direction within the cocoon as the exit holes made by the emerging adults are not always situated at any particular point, although they are most frequent towards the anterior end of the cocoon. These exit holes are rounded and have clean-cut edges while the exit holes in cocoons from which hyperparasites have emerged are usually with ragged edges.

The adult (fig. 19) has the head black, but with the clypeus and tips of the mandibles testaceous and the palpi yellowish. The antennae are slender, 19-segmented in the female and 21–22-segmented in the male, and are blackish in colour with the scape paler on its outside and apex, the second joint paler on its outside and base and the third joint sometimes paler at its base. The thorax is black and polished, the mesonotum with well-marked notauli and the propodeum feebly sculptured. The stigma is pale yellowish. The abdomen is dark brown and polished, with the first two segments (the second and third abdominal) frequently paler at their sides and apices, occasionally all paler. This pale coloration seems to be due to the contraction of the body contents and transparency of the sclerites, rather than to any pigmentation, as it is not visible in living specimens. The legs are yellowish with the claw-joints and apical tarsi blackish and the coxae and femora sometimes darker on the outside.

While *P. volucre* is the most important hymenopterous parasite of *H. arundinis* in Ireland, and therefore probably also in Great Britain, the amount of control it exercises cannot be estimated; it is probably of less importance than the larvae of the various aphidivorous Syrphid Diptera. The proportion of Aphides parasitised by it varies enormously in different parts of the trees, but speaking generally it is much lower—usually less than 5%—where there are a large number of Aphides feeding together and a large number of branches being attacked than where there are a few Aphides more or less isolated, when 50% or more may be parasitised towards the end of the season.

References.

Clausen, C. P., 1940, *Entomophagous Insects.*

Janiszewska, J., 1933, [Investigations on *Aphidius* sp., a hymenopterous parasite of the Aphid, *H. arundinis* F.] *Akad. Umiejetnósci* (*Cl. Sci. math. nat.*), *Bul. Int.* (B) **1933** : 277–293.

Marshall, T. A., 1899, A Monograph of the British Braconidae. *Trans. ent. Soc. Lond.* **1899** : 1–79.

Timberlake, P. H., 1910, Observations on the early stages of two Aphidiine parasites of Aphids. *Psyche* **17** : 125–130.

Wheeler, E. W., 1923, Some Braconids parasitic on Aphids and their life-history (Hym.). *Ann. ent. Soc. Amer.* **16** : 1–29.

NOTE ON THE BIONOMICS OF THE SPHEGID WASP *DASYPROCTUS BIPUNCTATUS* LEPELETIER (HYM.)

By Professor G. D. Hale CARPENTER, M.B.E., D.M., F.R.E.S.

DR. W. A. LAMBORN, O.B.E., in 1917 at Tanga on the E. African coast, made large collections of bionomic interest which he generously presented to the Hope Department of Entomology, Oxford University Museum. Opportunity recently arose for obtaining identification of a small Sphegid which had been found nesting in hollow stems during August; Dr. Lamborn sent several nests with specimens of the adult wasp, and of a species of Mutillid, that had emerged.

The wasp has been identified by Mr. G. E. J. Nixon of the Imperial Institute of Entomology as *Dasyproctus bipunctatus* Lepeletier, race *lichtenburgensis* Arnold, the Mutillid by Professor Clarence E. Mickel, of the University of Minnesota, as *Promecilla unicingulata* Bischoff, or possibly a variety differing by having the thorax black instead of dark red. Sundry flies forming the prey were identified by Dr. J. Smart of the British Museum (Nat. Hist.). Grateful acknowledgements are here made of the help of these gentlemen.

The prey is almost entirely the Ortalid fly *Rivellia trigona* Hendel, as shown by the following material from nests sent by Dr. Lamborn :—

1. 13 *Rivellia* from one cell with note " Two eggs of *Dasyproctus* on adjacent flies in cell."
2. 32 *Rivellia*, one specimen of another Ortalid *Aciura tetrachaeta* Bezzi, one Agromyzid and one Dolichopodid not determinable.
3. 37 *Rivellia*, one Agromyzid.
4. A. Cell 4 from top, 13 *Rivellia*. B. Cell 5 from top, fragments of 4 *Rivellia* and of two other flies probably *Rivellia*, with 13 loose wings of *Rivellia*.
5. 61 *Rivellia* from various cells of one nest.
6. 41 *Rivellia* from various cells of one nest.

Another stem laid open shows many *Rivellia*, *in situ*. A number of Mutillids, all females, emerged from other nests of *Dasyproctus*, and there is a note on one specimen by Dr. Lamborn to the effect that it emerged from an opened nest that had been kept in a box with the parent Mutillid.

ON THE STRUCTURE OF THE LEGS IN REDUVIIDAE (RHYNCHOTA)

By N. C. E. Miller, F.R.E.S., F.Z.S.

In spite of the appreciable amount of study devoted to the Reduviidae, knowledge of the habitual food of these insects under natural conditions is still relatively fragmentary; nevertheless, in captivity Reduviidae, both in the larval and adult stages, will readily accept and thrive on several kinds of insects which they are not likely to meet with in the wild state, for example, in life-cycle determinations carried out by me, larvae of *Diacalandra frumenti* Fabricius (Curculionidae) from dried maize, larvae of Trypetidae (Diptera) and adult Drosophilidae (Diptera) have proved satisfactory food material.

It is generally conceded that Reduviidae are mainly predators, some subsisting on other Arthropoda, others on the blood of mammals and birds, the latter being by far the fewer in numbers. Since it is not uncommon for Reduviidae to bite or attempt to bite when handled, it is possible that some of them, on this account, have been incorrectly included in the category of blood-suckers.

Statements to the effect that a greater number of Reduviidae than is commonly supposed is phytophagous have been published, but such statements appear to be based mostly on observations of a superficial nature and to have no foundation in fact.

As an example, the following observations on the habits of the Reduviidae, quoted by Distant (*Fauna Brit. India, Rhynchota* **2** : 196) from correspondence received from a friend in Bombay will illustrate a case in which it is obvious that a misinterpretation of the habits of one species has led to a generalised statement regarding the habits of the Reduviidae as a whole: "They feed chiefly on the mucilaginous juice of plants. The sharp, needle-like rostrum of the insect seems to fulfil a very important biologic function. It generally pierces the inner bark of a plant and discharges into the wound an acrid, poisonous fluid which rarefies the mucilaginous sap and helps the setae to suck the juice with ease and convenience, evidently doing no harm to the plant, but, on the contrary, promoting the exudation of the valuable sap. Hence there is reason to believe that the gums, resins and other resinous vegetable products of commercial value depend largely on the punctures made by the Reduviids. The blood-sucking propensities of some of the species are, I believe, due to a habit probably for the purpose of self-defence."

The observations just quoted seem to me to have originated from a cursory examination of one of the Apiomerinae, to the habits of which further reference will be made in this paper.

That Reduviidae may in time of moisture shortage suck the sap of plants is by no means unlikely, but no information on the subject is available. Larval *Rhinocoris marginellus* Thunberg have been observed to suck up raindrops from leaf surfaces.

Assuming therefore that Reduviidae are mainly predators, it is somewhat astonishing that few possess anterior legs of the true raptorial type, that is to say, if one accepts the definition of raptorial legs as those legs which have an armature of spines on the lower surface of the anterior femora and tibiae, or are

so shaped that they form a kind of pincers, like the anterior legs of the PHYMATIDAE, NEPIDAE and BELOSTOMATIDAE.

In *Laccotrephes robustus* Stål (NEPIDAE) the lower surface of the anterior femora, tibiae and basal segment of the anterior tarsi is covered with dense, short, erect setae, and a similar arrangement of setae may be seen in *Lethocerus indicus* (Lepeletier & Serville) (BELOSTOMATIDAE), but in this species the setae are present on all legs.

Superficially, these areas bear a strong resemblance to the " spongy area " on the legs of certain REDUVIIDAE. Close examination, however, reveals that the area covered by these setae is not less sclerotised than the remaining non-setose surfaces.

Although the possession of raptorial legs is not an outstanding characteristic of the REDUVIIDAE, it is noteworthy that this fact has been disregarded by certain well-known writers, as the following quotations will show : " Les insectes de cette famille se nourissent de matières animales, et la plupart, sans doute, en faisant la chasse à d'autres insectes. La Nature les a pourvus à cette effet de pattes anterieures faites pour saisir une proie ; les cuisses ordinairement épaissies, présentent en dessous une rainure longitudinale pour recevoir la jambe ; celles-ci sont garnies au côte interne de fines dents ou brosses propres à retenir ce qu'elles embrassent " (1843, Amyot, C. J. B., et Serville, A., *Hemiptères*) ; " The species are highly carnivorous and feed on living prey as indicated by the raptorial character of their forelegs " (1923, Butler, E. A., *A Biology of the British Hemiptera–Heteroptera*) ; " Die Vorderbeine der Nabiden sind ebenso wie die der Reduviiden auffallend verdickt ; Mittelgrosse bis grosse Tiere mit verdickten, als Raubbeine dienenden Vorderbeinen " (1930, Weber, H., *Biologie der Hemipteren*).

The true raptorial type of anterior leg is confined to the subfamily EMESINAE, but anterior legs approaching the raptorial type are found in the genera *Gallobelgicus*, *Irantha*, and *Polydidus*. Thickened femora with short spines or serrations on the lower surface are present in many genera.

The genera *Agyrius* and *Rihirbus* have thickened anterior femora and somewhat curved anterior tibiae, *Rihirbus* also having a subacute spine near the apex of the tibiae and the lower surface of the femora very densely setose, the setae being short and erect. The anterior legs of these genera also approach the raptorial type.

In most species the anterior tibiae are provided with dense setae apically which may enhance the gripping power of the legs, but in some species there is present a peculiar structure known as the "*fossula spongiosa*" or " spongy furrow," referred to previously in this paper as the " spongy area, " a term which I consider more appropriate. The descriptions "*fossula spongiosa*" and " spongy furrow " can be applied with accuracy only in the case of dried specimens, since in living specimens the structure is not sulcate, but on the contrary has a convex surface. Furthermore, even in dried specimens the part is not invariably sulcate, its conformation depending on the manner in which it has been affected by desiccation.

This structure, according to Amyot and Serville, was observed, apparently for the first time, by Latreille (1807, *Gen. Crust. Ins.* **3**), who, however, did not express an opinion regarding its probable function.

Dufour, who referred to it as the " fossette spongieuse " of the anterior legs, states " ce corps placé au dessus du tarse et d'une forme ovalaire est charnu, pulpeux et sa surface inférieure paraît au microscope couverte d'un duvet excessivement court, semblable à celui du velours. C'est une veritable

pelote spongieuse, un organe eminement fonctionel destiné à exercer l'acte du toucher et de la préhension, et adapté aux habitudes d'un insecte essentiellement chasseur " (1833, Dufour, L., *Ann. Soc. ent. Fr.* **3**).

From Dufour's observations it is evident that he made more than a superficial examination of the part in both living and dead specimens, but, although he referred to it both as a " fossette " and an oval fleshy body, he does not emphasise the fact that it is in dried specimens only that it can be described accurately by the former term.

Dufour somewhat vaguely intimated that the "*fossula*" has some connection with predacious habits, and while he agreed that REDUVIIDAE are essentially predacious insects he does not indicate that the part is not present in all representatives of this family.

The "*fossula spongiosa*" has been referred to by various systematists since the publication of the observations of the writers referred to, but, as far as I am aware, it was not until 1932 that attention was once more drawn to it and a preliminary examination carried out, the Reduviid concerned being *Rhodnius prolixus* Stål (1932, Gillett, J. D., *Entomologist* **65**).

Gillett states that he noticed that adult *Rhodnius* were able to climb a vertical glass surface, a fact which drew his attention to the presence of a fleshy pad at the apex of the tibiae of the anterior and median legs. In view of the ability of the insect to climb a smooth surface, he concluded that the structure must be a climbing organ.

A more detailed account of its structure and mechanism was drawn up in the same year, and the opinion that the structure is a climbing organ was reaffirmed (Gillett, J. D., and Wigglesworth, V. B., The climbing Organ of an Insect *Rhodnius prolixus* (Hemiptera REDUVIIDAE), 1932, *Proc. Roy. Soc.* **111**: 364–376).

In this account Gillett and Wigglesworth also state: " An homologous structure known as the '*fossa spongiosa tibiarum*' is present in the majority of the REDUVIIDAE." This, however, is not the case, but, on the contrary, the majority of REDUVIIDAE do not possess it, a fact which may be confirmed by the examination of one subfamily alone—the HARPACTORINAE—which contains the largest number of genera, none of which has this structure.

Some years later I contested the opinion of Gillett and Wigglesworth that the structure is a climbing organ, in view of the fact that in many species it is not restricted to the apex of the tibiae, but, on the contrary, frequently extends along almost the entire length of the lower surface, and that when the insect is walking or stationary, only the apex of the tibia comes into contact with the surface on which the insect happens to be (1938, Miller, N. C. E., *Nature* **141**).

A theory was put forward by me (*loc. cit.*) that the function of the "*fossula*" is mainly to enhance the gripping qualities of the legs during the capture of prey. This theory is supported by another worker who, in referring to the subfamily PIRATINAE, states that " they have both anterior pairs of legs equipped with soft, spongy pads covered with short, thickly-set hairs, the function of which seems to be to hold on to the smooth bodies of insects " (1927, Readio, P. A., Studies on the Biology of the REDUVIIDAE of America north of Mexico; *Kansas Univ. Sci. Bull.* **17**).

A further reference to the function of the structure is made by Readio (*loc. cit.*) in respect of the habits of *Melanolestes picipes* (Herrich-Schaeffer), a species which is to be found in contact with the soil, beneath rocks and logs.

Several adults of this species were supplied with a miscellaneous assortment

of insect food which comprised " cutworms " (larvae of NOCTUIDAE), cranefly larvae (TIPULIDAE), larvae of the clover-leaf weevil *Phytonomus posticus* (CURCULIONIDAE), larvae of soldier beetles (CANTHARIDAE), larvae of May beetles, grasshoppers (OEDIPODINAE), Phalangids and ONISCIDAE, but from these only the May beetle larvae were accepted. When adult May beetles made their appearance they were supplied and accepted with a readiness which reliably indicated that they formed the principal food of the bug.

After describing the attack by *Melanolestes* on an adult May beetle, Readio states : " The part that the spongy pads on the tibiae of the front legs of the assassin bug play in this attack is very important. They are admirably adapted for holding on to the smooth and shining wing covers and prothorax of the beetle and there can be no doubt that this is their intended function."

Among Malaysian species which have a similar habitat, that is to say, are mainly dwellers in the soil, are *Ectrychotes crudelis* Fabricius, and other species of *Ectrychotes* and *Scadra* of the subfamily ECTRICHODIINAE. In soil in which these Reduviids have been found a varied population of Arthropoda, including many Diplopoda, was present.

During the periods that these Reduviids were kept under observation in the laboratory they were supplied with larvae of *Spodoptera pecten* Guenée (NOCTUIDAE), and also with Diplopod–animals with a hard, smooth integument which they attacked and devoured without hesitation, and it appeared that the power of these Reduviids to overcome a prey at least twice as big as themselves could be attributed to the fact that their tibiae are provided with a "*fossula*."

In a later communication on the subject of the "*fossula*," Wigglesworth suggested that it would perhaps be preferable to refer to the structure as an adhesive organ, a term which could be used without prejudice to the question of its normal function (1938, Wigglesworth, V. B., *Nature* **141**).

Indications of the probable function of adhesive organs have also been given by this worker, who states : " Such organs may be of value, of course, not only in clinging to smooth surfaces but for gripping smooth objects such as the bodies of insects " (1939, Wigglesworth, V. B., *The Principles of Insect Physiology*).

Regarding *Rhodnius prolixus* I have also stated that the " *fossula* " was possibly a vestigial organ, the reason for this opinion being that this species has probably not always preyed on mammals, but had been, in common with the majority of REDUVIIDAE, a predator on other insects. Taking into consideration the habits and also the habitat of this species it seemed that the "*fossula* " would no longer be essential to assist the insect in climbing or in the capture of its prey, and consequently had degenerated (1938, Miller, N. C. E., *Nature* **141**).

On further consideration, however, it is admitted that this is not so, the structure as described by Gillett and Wigglesworth clearly indicating that one is not dealing with a vestigial organ.

A subsidiary function of the "*fossula* " is to enable the possessor to clean itself, an operation which may be frequently witnessed when specimens are kept in captivity. During such operations the insect draws its antennae or rostrum between the anterior tibiae which it presses closely one against the other. The head and thorax are freed from undesirable substances by the anterior and median tibiae and the abdomen and hemielytra are similarly served by the posterior tibiae. It has also been observed that the posterior tibiae in the male are used to remove from the genital segment any spermatozoa

which may remain after copulation. The Reduviid in which this act was witnessed was *Rhinocoris marginellus* Thunberg (HARPACTORINAE).

The view that the "*fossula*" is a sexual character cannot be maintained, since in the species in which it is present it is equally well developed in both sexes. Moreover, during copulation the male obtains a firm grip on the female by means of the tarsal claws, whether the "*fossula*" is present or not.

It may be remarked here that most insects of small size and light weight are able to cling to and move about on smooth surfaces inclined at any angle, a firm grip being obtained by means of tarsal pads and pulvilli. Nevertheless, there are exceptions, for example certain ASILIDAE (*Synolcus xanthopus* Wiedemann and *Philodiscus fuscipes* Richards) (Diptera) which I captured for the purpose of examining the legs and to ascertain whether, in another kind of insect having predacious habits, they were particularly adapted for capturing prey.

These flies were confined in glass tubes and it was noticed that they were unable to cling to the sides when the tubes were inclined at an angle, and when the tubes were held in a vertical position the flies were quite incapable of ascending the sides. It should be pointed out that the tubes in which these flies were enclosed were far from clean.

All the legs of the ASILIDAE in question are provided with abundant, robust setae, the median and posterior tibiae in addition having shorter setae arranged in dense, linear areas on the inner surface. The pulvilli on all legs are well developed.

The ability of REDUVIIDAE to climb smooth surfaces has been investigated by me, the following being used in the tests: *Canthesancus helluo* Stål (STENOPODINAE, adult), *Velitra rubropicta* Amyot & Serville (ACANTHASPINAE, adult), *Mendis semirufa* Stål (ECTRICHODIINAE, larvae and adults), *Ectrychotes* sp. (ECTRICHODIINAE, adults), *Vesbius purpureus* Thunberg (HARPACTORINAE, larvae and adults), *Scipinia* sp. (HARPACTORINAE, larva and adult), *Cosmolestes picticeps* Stål (HARPACTORINAE, larvae and adults) and *Rhinocoris fuscipes* F. (HARPACTORINAE, adult) (1939, Miller, N. C. E., *Nature* **143**).

M. semirufa, *Ectrychotes* sp. and *V. rubropicta* were able to climb up the sides of a glass vessel inclined at an angle of 80°; *C. helluo*, a large insect, could maintain its position when the side of the vessel was vertical or horizontal (the insect hanging with the dorsal surface downwards); *V. purpureus*, both larvae and adults, had no difficulty in clinging to the glass in whatever position it was held. *R. fuscipes* and *C. picticeps* were able to climb the sides of a glass tube inclined at an angle of 50°; when the position of the tube was altered to vertical, *C. picticeps* was still able to climb but with considerable difficulty, progression being in a spiral fashion and not directly upwards. When moving in a downward direction it experienced some difficulty in avoiding slipping. *Scipinia* were able to move about in any direction. This genus as well as *Vesbius*, *Cosmolestes* and *Rhinocoris* have no "*fossula*" on the tibiae.

From the foregoing it will be seen that REDUVIIDAE with a "*fossula*" are about equally efficient, under artificial conditions, in negotiating smooth surfaces as those which are not so provided.

In *Isyndus heros* F., and in some other members of the HARPACTORINAE, the lower surface of the apex of the anterior tibiae is much less sclerotised and consequently more elastic than the remainder of the tibia. A longitudinal section of the apex of the anterior tibia of *I. heros* has revealed that the setae are mostly of a simple type, but those situated at the extreme apex are somewhat wider and curved apically. This modification is present on the median

and posterior tibiae but is a little less extensive; the setae, however, being similar to those on the anterior tibiae. The modified part, being more sclerotised than a typical "*fossula*," does not shrink after the death of the insect.

The theory is here put forward that there may be some relation between the extent of development and consequent greater efficiency of the "*fossula*" and the virulence of the saliva, but it is obvious that reliable data in this connection cannot be obtained. This theory, from a human point of view, is untenable, the bite of most REDUVIIDAE whether provided with a "*fossula*" or not being painful and productive of inflammation of the affected part.

In the case of one species, *Platymerus rhadamanthus* Gerstäcker (ACANTHASPINAE), a large red and black insect inhabiting East Africa, the bite causes intense pain which persists for several hours. This species, which was captured by me on one occasion in Tanganyika Territory, has a well-developed "*fossula*"; nevertheless, the reason for the combination of this and a high degree of virulence of the saliva might be apparent if the habitual food of this large insect were known and if the effects of its bite on another insect or on a small mammal, and also its method of capturing its prey, could be witnessed.

The paralysing action of the saliva of REDUVIIDAE is usually rapid and it is an uncommon occurrence for an insect which has been attacked to be capable of movement for more than a few seconds after being pierced by the mouthparts.

It is remarkable, however, that the saliva apparently may not invariably have adverse effects if injected into the body of another Reduviid of the same species, a fact which has been recorded in respect of a species of *Triatoma*. The observer in this instance stated that the individual sucked is not troubled by the operation (at least he did not witness its death) and that he regards the habit as an ancestral survival of normal entomophagous habits of REDUVIIDAE, which persist even among those species which suck mammalian blood (1914, Brumpt, E., Importance du cannibalisme et de la coprophagie chez les Reduvidés hématophages pathogènes en dehors de l'hôte vertebré, *Bull. Soc. Path. exot.* **7**).

A similar occurrence has also been recorded in larval *Triatoma flavida* which have been seen to suck blood from the body of the mother bug and also from each other without harmful effects. This habit is apparently a normal one (1916, Hoffmann, W. H., *Rev. Par. Habana* **2** (4A)). In such cases it would seem probable that the blood ingested from the individuals which are sucked is in a condition which does not require a further addition of saliva to render it assimilable, thus no injection of saliva takes place. Cannibalism among larval and adult REDUVIIDAE (non-bloodsuckers) in captivity, particularly if there is overcrowding, has frequently been observed by me, but in every case the victim has succumbed.

Referring again to the subject of phytophagous habits of REDUVIIDAE, one is reminded of Distant's note on *Amulius longiceps* Stål, a member of the APIOMERINAE (1903, Distant, W. L., *Fasc. Malay.* **2**). According to this writer, who is apparently quoting the observations of the collector of the insect, *A. longiceps* is found on trees on the sticky exudation of which it feeds. Its body is also stated to be covered with the sticky substance. The fact that this and other members of the subfamily have usually a coating of sticky resinous matter on the body and legs is well known. Nevertheless, the actual reason for its presence is not that the insects become smeared with it while they are feeding but that they deliberately dip their anterior legs into the substance which

is then used as a snare for their prey, which consists largely of small bees (*Trigona*).

Accurate observations on a member of the APIOMERINAE were apparently first made in Surinam in 1901 by Uyttenboogart who, in order to prove whether the resinous substance was actually secreted by the insect or obtained in some other way, removed the accumulation from the anterior tibiae by means of alcohol. He observed that shortly afterwards, however, the treated insect had obtained a fresh supply of the sticky substance, and that it was able to capture its prey by means of it (1932, Roepke, W., Über Harzwanzen von Sumatra und Java, *Misc. Zool. Sumatr.* **68**).

Roepke (*loc. cit.*), when describing a new species of *Amulius*, *sumatranus*, published further details regarding this remarkable habit which, it would appear, is confined to the APIOMERINAE. *Ectinoderus*, another genus which has habits similar to *Amulius*, utilises the resinous exudations of trees in the same manner, and should also be included in the category of Roepke's " Harzwanzen " or " resin bugs."

The reason for the mention of this phenomenon is to draw attention to the structure of the anterior tibiae of *Amulius* and *Ectinoderus*. These are devoid of spines or other armature and are cylindrical, relatively thick and somewhat densely setose, the setae being rather silky.

It is noteworthy also that as in insects possessing true raptorial anterior legs, these legs, when covered with resin, are not used for walking. The claws are absent from the anterior tibiae of the larvae and are considerably reduced in size in the adults.

When the insects are at rest they lie rather flat on the tree-trunk and hold the anterior legs so that the femoro-tibial articulation is directed backwards, an attitude similar to that adopted by certain other Reduviids, namely *Agyrius podagricus* Stål, *Biasticus moultoni* Distant, and *Rhinocoris flavus* Distant, to mention a few species only.

A female *Amulius armillatus* Breddin was observed on one occasion by me. This individual was stationary on a jungle tree with its head directed towards the base of the tree, and the anterior legs were held in the manner just described. At the same time, it swayed its body from side to side. The specimen was captured and it was noticed that after a comparatively short time the resinous accretions gradually disappeared and were not renewed, a circumstance which offers additional evidence that the substance is not secreted by the insect itself. The actual smearing of the anterior legs with an adhesive substance has been observed on more than one occasion by me in the case of larvae and adults of *Amulius malayus* Stål under observation in captivity.

In an attempt to solve the difficulty of providing a suitable resin for the use of these Reduviids, a small glass capsule containing gum arabic partly dissolved in water was placed in the breeding cage; shortly afterwards, and on later occasions, the Reduviids were seen to dip their anterior tibiae into the gum, one tibia applying it to the other alternately. In spite of the somewhat rapid drying and hardening qualities of this gum, the mass accumulated on the tibiae did not appear to offer an obstacle to the capture of the insects (small Tettigoniids, Diptera, *Lucilia* sp. and *Orthellia* sp.) supplied for their food.

An interesting observation has been made on the genus *Apiomerus*, which is confined to the neotropical and nearctic regions. This reveals that : " The females have the power of exuding a sticky fluid from the ventral surface and probably from the tibiae also ; the hairs on the venter are matted and stuck together with this substance in nearly all the specimens examined. From what

I have observed of the habits of one of the largest species, *A. vexillarius*, which is quite common in forest clearings in the 'terra caliente' of Chirique, this viscous fluid appeared to be used for the purpose of securing a firm grasp of its prey—freshly-emerged Longicornia etc. nearly as large as itself—during the process of suction" (1898, Champion, G. C., *Biologia Centrali Americana*).

Certain other Reduviidae also secrete an adhesive substance from glandular setae situated on the thorax and abdomen. One of the best-known of these is the widely distributed *Reduvius personatus* L., which owes its specific name to its habits of covering itself with debris made up of grains of soil and small pieces of animal and vegetable matter. This debris is deliberately collected and placed in position by the bug on the glandular setae to which it adheres. The same habit has been observed by me in *Reduvius gua* Dover, a species inhabiting dark limestone caves in the vicinity of Kuala Lumpur, Malaya, and also in a species of *Acanthaspis*, two fourth-instar larvae of which were found under part of a nest of a *Eutermes* sp. constructed on a dead tree-trunk. They were kept under observation for some days, and during the period of captivity it was remarked that they denuded themselves of the debris, only to renew it shortly afterwards. Another larval *Acanthaspis* with a certain amount of debris adhering to it and attended by ants has also come under notice.

The significance of this habit has been interpreted in various ways, one theory being that the debris is accumulated on the body for protective purposes, but it would seem that the value of such a device to an animal such as *Reduvius gua*, which passes its whole existence in the pitch-dark conditions which prevail in the caves referred to, is problematical.

As regards the adhesive substance, it is pertinent to point out that in the Apiomerinae it forms a more or less thick film on the legs (chiefly the anterior pair) and on the body, the anterior legs being sometimes so thickly covered that the tarsi are concealed. In the Acanthaspinae it remains on the setae, and as far as it has been possible to ascertain, it does not spread extensively on to the body.

The ability to secrete an adhesive substance from glandular setae is possessed by certain Harpactorinae—*Cosmolestes picticeps* Stål, *Sphedanolestes flaviventris* Distant, *Rhinocoris fuscipes* F. and *Velinus malayus* Stål. In these Reduviids, however, the deliberate accumulation of debris is not practised. The habitat favoured by *C. picticeps* and *V. malayus* is mostly rough herbage in clearings or along cultivated areas and on the outskirts of jungle; the former is also often seen in gardens on flowering plants such as *Angelonia* sp.

Among the many species in the assemblage of plants growing on the margin of jungle in Malaya, one of the most abundant is *Passiflora foetida* L., from the fimbriate involucres of which a tenuous adhesive substance is put forth, a fact which led me to believe that the adhesive matter present on some *C. picticeps* and *V. malayus* which I captured on *P. foetida* was none other than that produced by this plant and purposely collected by these Reduviids. Subsequent examination, however, showed that the adhesive substance originated from glandular setae. It is noteworthy also that *R. fuscipes* is frequently found on a plant which produces an adhesive substance from glandular hairs situated on the leaf margins and on the stems. This plant is *Jatropha glandulifera* Roxb. (Euphorbiaceae), one of the host-plants of *Pseudococcus filamentosus* Cockerell (Coccidae) on which *R. fuscipes* preys.

In *Agriolestes* sp. (Harpactorinae) an adhesive substance may be observed on the legs of larvae and adults (the quantity being greater in the larvae); however, it does not appear to originate from glandular setae but from setal

alveoles. As well as forming small globules on the setae, the substances may also form a thin film on the body and legs. Specimens in captivity do not seem to secrete as great a quantity as those living under natural conditions.

The anterior tibiae of the HARPACTORINAE, with a few exceptions, are simple and in some genera, *e.g.* *Sycanus* and *Rhinocoris* which feed on lepidopterous larvae and COCCIDAE (Mealybugs), are not employed, as a rule, to grasp the prey, the immobilisation of which (in the case of the larvae) is effected by a swift piercing by the stylets and the injection of saliva. After the prey has been despatched, these Reduviids may sometimes be seen to walk about with it impaled on the rostrum. These genera are mainly diurnal and often frequent flowering plants.

The habit of moving about with the prey transfixed by the stylets has also been noticed in the subfamily ASOPINAE of the PENTATOMIDAE, in which predacious habits predominate in the adults but from which the raptorial type of anterior legs is absent. With these bugs there is generally no food specialisation, but observations have shown that their prey consists mainly of the developmental stages of insects which can generally be overcome without difficulty, any resistance to attack which might be met with and which might be effective being the convulsive wriggling of a larva.

Some REDUVIIDAE, as previously stated, have a "*fossula*" on the median tibiae as well as on the anterior tibiae. It is usually not quite as extensive, however, as that on the anterior tibiae. In most genera both the median and posterior tibiae are simple, that is to say, have no armature, but have setae of varying degrees of abundance, the setae being short, more robust and denser on the lower surface of the apex. Anterior tibiae with a short sulcus on the upper surface apically in which the tarsus is able to lie are present in *Valentia* (SALYAVATINAE). This subfamily also contains the genera *Lisarda*, *Petalochirus* and *Syberna*. In *Valentia* the anterior tibiae are widened and thickened at the apex. In *Petalochirus* the whole tibia is laterally compressed and expanded and in *Syberna* the tibia is compressed but feebly and irregularly expanded. *Lisarda* has the anterior tibiae somewhat thicker apically. A "*fossula*" of various degrees of development is present in these genera.

The purpose of this paper which, it is emphasised, is of a preliminary nature, is to draw attention to some misconceptions regarding the structure of the legs in REDUVIIDAE, these misconceptions usually originating from the repetition in textbooks and other publications of generalised statements with regard to certain aspects of the morphology of members of this family.

Particular reference is made to the structure of the anterior and median tibiae and also to investigations into the structure and probable function of the tibial organ known as the "*fossula spongiosa*."

It is considered that additional light may be thrown on the question of the function of the "*fossula*" as more information regarding food preferences of this family is forthcoming. This information, needless to say, is not easily obtainable owing to the fact that REDUVIIDAE, particularly those which are nocturnal or which pass most of their lifetime in concealment, are not often seen with their prey; furthermore, it would be unsafe to conclude that although certain species in captivity will readily accept insect food of a particular kind, they would necessarily seek similar food in their natural surroundings.

Finally, attention is drawn to the fact that the observations set forth in this paper are based almost exclusively on a study of Malaysian REDUVIIDAE, some genera of which, however, are represented in other regions.

I am indebted to Mr. H. M. Pendlebury, Director of Museums, Federated Malay States, and to Mr. W. E. China, M.A., of the British Museum (Natural History), London, for helpful advice and criticisms. It must be pointed out, however, that Mr. China is not wholly in agreement with some of the remarks regarding the "*fossula spongiosa.*"

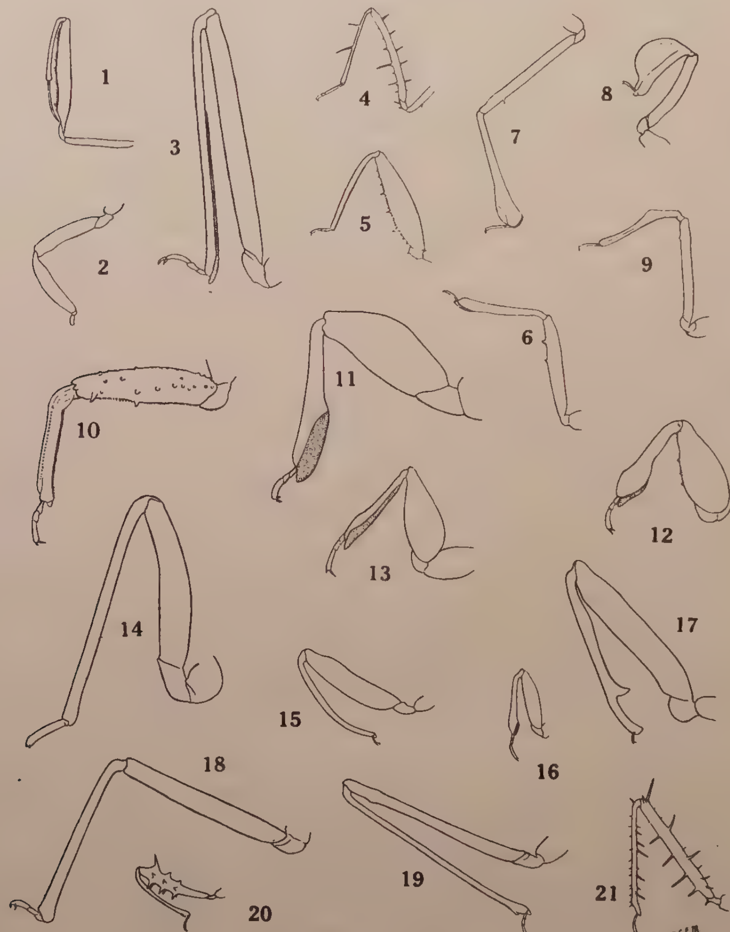


FIG. 1.—1. *Bagauda lucifugus* McAttee & Malloch; 2. *Aulacogenia patalungae* Miller; 3. *Canthesancus helluo* Stål; 4. *Gallobelgicus kinabaluensis* Miller; 5. *Sastrapada aculeata* Miller; 6. *Lisarda inornata* Walker; 7. *Valentia langkawiensis* Miller; 8. *Petalochirus gulosus* Miller; 9. *Syberna munita* (Walker); 10. *Centrocnemis signoreti* Stål; 11. *Tiarodes hieroglyphicus* Miller; 12. *Pirates lugubris* Miller; 13. *Ectomocoris elegans* F.; 14. *Amulius armillatus* Breddin; 15. *Agyrius podagricus* Stål; 16. *Ectrychotes crudelis* F.; 17. *Rihirbus* sp.; 18. *Isyndus heros* F.; 19. *Sycanus leucomesus* Walker; 20. *Irantha* sp.; 21. *Polydidus armatissimus* Stål.

Examples of some of the types of anterior legs of REDUVIIDAE are given in fig. 1.

THREE REMARKABLE STRIDULATORY MECHANISMS IN ACRIDIDAE (ORTHOPTERA)

By G. M. Henry, F.R.E.S.

Charora crassivenosa Saussure 1888.

I AM indebted to Dr. B. P. Uvarov for drawing my attention to the interesting stridulatory mechanism in this species. Its existence was noted by Bolivar in his description of the allied *Ch. pentagrammica* (1899, *Ann. Soc. ent. Belg.* **43** : 592) but he did not figure it; Saussure (1888, *Addit. Prodr. Oedipod.* : 71) apparently missed it altogether.

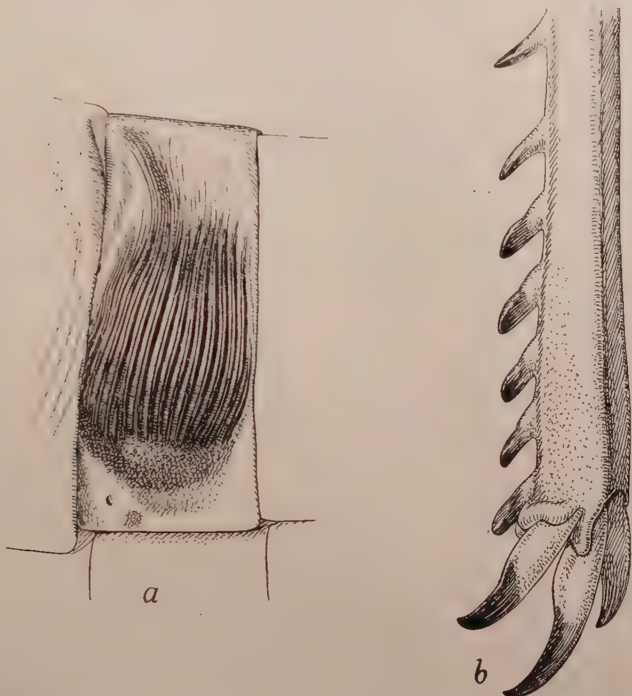


Fig. 1.—*Charora crassivenosa* Saussure, ♂. a, 6th tergite, left side, showing striated patch; b, left hind tibia, inner side, showing modified distal spines.

Tergites 4–8 of the abdomen possess on their sides roughly circular patches consisting of series of strong, parallel chitinous ridges, each separated from its neighbour by a groove of about the same depth and width as the height and width of the ridge; the ridges are set almost vertically, and number on each tergite about 16–20; their general appearance and arrangement can be seen in fig. 1, a, which represents the sixth tergite, on which the ridges are best developed; behind this segment the ridged patches become progressively smaller, and in front of it, too, they decrease in size, though less strongly. The ridged patches and a small area ventral to them are dark brown in colour, contrasting strongly with the pale testaceous ground colour. In *C. pentagrammica* the ridged patches are not distinctively pigmented and have a transparent appearance suggestive of air spaces below them; they are confined to tergites 5–8, and the ridges are less numerous, 10–12 per tergite.

The necessary scraper for use with the ridged patches appears to be provided in the distal inner spines of the hind tibiae; these spines are somewhat compressed laterally and terminate in a sharp, rounded edge (fig. 1, b). Experiment with a relaxed specimen indicates that a rasping sound can be elicited by scraping these tibial spines across the ridged tergites; however, proof of the actual method of stridulation must await observation of the living insect.

In addition to the abdominal-hind tibial stridulatory specialisation in *Charora*, the males of this genus possess a strong modification of the hind-wings in the form of greatly thickened veins along the costal margin; these are followed by an area of enlarged, tympanate areoles suggestive of a vibratory function. It seems highly probable that this is a sound-producing organ of some sort, but it appears to have no correlation with the abdominal ridges and is probably used for the production of sound while in flight.

In *Egnatioides farsistanicus* Uvarov, which belongs to the same group as *Charora*, the sides of the tergites show an interesting transition-stage between the ordinary smooth condition of most Acrididae and the highly specialised ridged patches of *Charora*. In this, the sides of the tergites show irregular, vertical puckering, which, above and below, passes into shallow puncturing of a normal type.

It is to be hoped that entomologists in Asia Minor and Iran will pay special attention to the study of living examples of these two genera, in order to observe their actual stridulatory behaviour.

Phonogaster cariniventris Henry 1940.

This species (for description see Henry 1940, *Trans. R. ent. Soc. Lond.* **90** : 508) was captured by the British Museum–Colombo Museum Expedition to South India, 1937—at Dhimbam and Hasanur, near the southern edge of the Mysore Plateau (not actually in Mysore State), in grassland with a thin cover of small trees. The males possess a remarkable stridulatory apparatus similar in general principle to that of the strange African Acridians of the family Pneumoridae and quite distinct from the type found in the great bulk of the subfamily Acridinae, to which the species belongs. In most Acridinae, a row of tiny pegs on the inner face of the hind femur is used to rasp a ridged vein (usually *R*) of the closed tegmen; the latter has the costal area, or some other area, enlarged, with expanded and tympanate areoles, which provide the necessary vibratory surfaces. *Phonogaster*, while possessing the familiar row of femoral tubercles (fig. 2, d, e), shows no trace of either a ridged vein or expanded areas on the tegmen. Instead, the sides of tergites 3–5 possess two sub-parallel, fine chitinous ridges (fig. 2, a, b, c), which run longitudinally and provide the " scrapers " for the femoral tubercles to rasp. Were the abdomen to be lined with the usual layers of muscle and other tissues in this region, it is obvious that, at best, a very feeble sound could be produced; however, even a superficial examination of the abdomen reveals that tergites 3–6 are not normally occupied by tissues, as they have a translucent and " blistery " appearance, and transmitted light shows them to be quite hollow. They are occupied by large air-sacs disposed as shown in fig. 2, a. A transverse section of a tergite (fig. 2, b) reveals that these air sacs, as is to be expected, are paired structures separated by a median thin septum (doubtless morphologically double-walled) composed of membrane of the same character as ordinary tracheal air-sacs. In the specimen dissected, the septum was, as shown in the figure, asymmetrically disposed, but this was probably an accidental abnormality. (In two dissected specimens of *Pneumora* in which the general structure of abdominal air-sacs is

similar to that of *Phonogaster*, one had the membranous septum median, while the other had it strongly displaced to the left.) Each segment has its own pair of air-sacs, but these are not exactly co-extensive with their own tergite, overlapping into the succeeding tergite to some extent. The anterior point of attachment of an air-sac to its tergite is marked externally by an oblique impressed line near the anterior margin of the tergite, as can be seen in fig. 2, a.

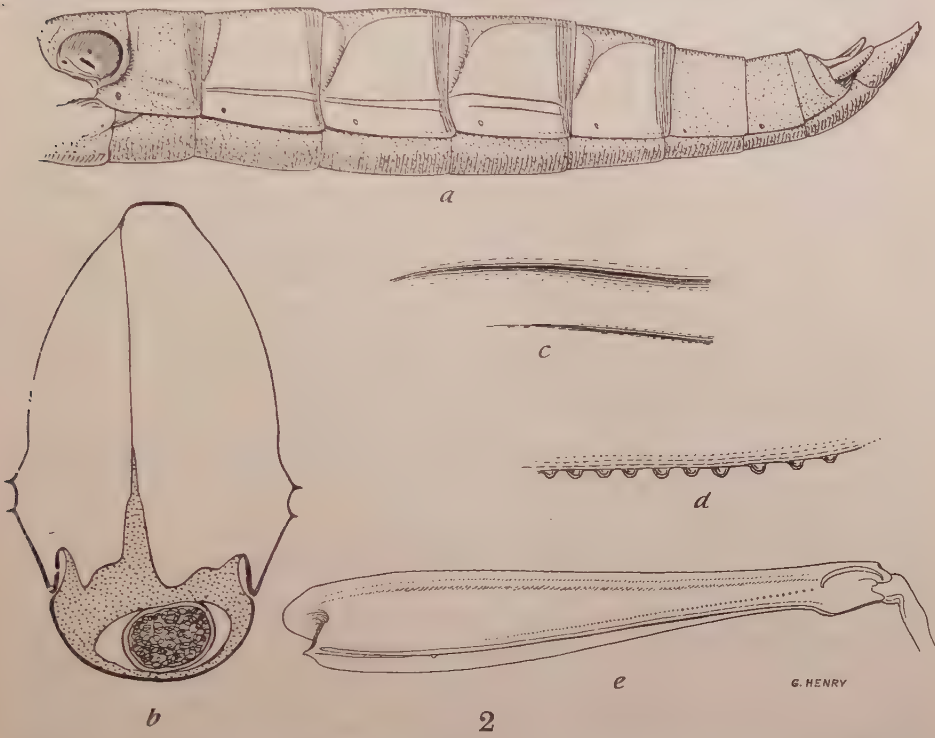


Fig. 2.—*Phonogaster cariniventris* Henry, ♂. a, abdomen, showing lateral ridges and tympanate tergites; b, abdomen, transverse section of 5th segment, showing lateral ridges and large air-sacs; c, 1 mm. of ridges on 5th tergite, greatly magnified; d, right hind femoral knobs, distal portion of row, dorsal aspect; e, right hind femur, inner side, showing row of knobs.

The tergites of the female show no trace of the tympanate characters of the male, and the scraper-ridges on their sides are represented merely by feeble longitudinal puckers.

On the hind femur, the row of small tubercles extends nearly to the hind knee (fig. 2, e); proximally the tubercles are small and rather irregular, becoming larger distally. In many Acridinae, such as *Aulacobothrus*, the row consists of small, articulated pegs, formed really of modified setae; in *Phonogaster* the row appears to consist rather of tubercles (fig. 2, d) suggestive of modifications of the sculpturing of the chitin rather than of modified setae. The settling of this point, however, must await the collection of fresh material.

Mesambria dubia Walker 1870.

The male of this common Ceylonese Acridian stridulates loudly when seized. The sound, which may be roughly described as a shrill creaking, is clearly

associated with movements of the mandibles, which are partially opened and closed in time with the beats of sound—perhaps two or three creaks in a second of time. Dissections of the mouth-parts reveal no trace of a " file-and-scraper " mechanism, but the mandibular teeth are worn into facets or planes by rubbing together, and I have no doubt that this is the method of producing the sound. Observation of a living specimen under a binocular microscope established the facts that stridulation can take place if the labrum is reflected back over the clypeus and that it is inhibited by the flooding of the parts with the brown fluid disgorged from the crop by the insect under stress of being held.

The female has not been observed to stridulate, and I have no evidence that the male does so unless it is seized.

A somewhat similar method of sound production in an Acridian, *Oedaleonotus fuscipes* Scudder, has recently been recorded by Varley (1939, *Proc. R. ent. Soc. Lond* (A) **14** : 99), but in that species the sound produced by the mandibles was described as a click, apparently produced by the sudden snapping of the mandibles, after " catching " their tips. The clicking sound is apparently made by the insect in freedom, and seems to have some sexual or social significance. In *Mesambria dubia*, of which numerous specimens of both sexes have been kept for long periods under observation in my cages, no evidence that the sound produced by the males has any such significance has appeared.

JOHN SANG'S ORIGINAL DRAWINGS OF BRITISH COLEOPTERA AND LEPIDOPTERA, WITH A NOTE ON DR. P. B. MASON'S COLLECTIONS

By H. Willoughby Ellis, M.I.E.E., F.R.E.S., F.Z.S.

Entomological figures have always been a contentious subject, and authors from quite early times have considered that a figure, plain or coloured, good or bad, mostly the latter, was necessary to embellish their remarks and there is, therefore, a mass of figures in entomological literature which has little value in proportion to the library space it occupies. Figures are continually published in magazines and books which, if left plain and drawn with some regard for the characters to be illustrated, rather than coloured, would have some real value, but as it is are pretty pictures maybe, but scientifically little more than smudges. John Sang (1828–1887) [1] was a great exponent of delineation and his work is of super excellence; in common with fine miniatures, his figures will bear microscopical study without in the least degree diminishing their scientific accuracy and value.

Of the seven volumes containing his drawings, one is devoted to coloured figures of some of the smaller moths, Pyrales and Tineidae, on which groups Sang was a recognised authority. He included in the series the whole of the then known species, and, in the case of the Nepticulae, the food-plants showing the mines are mounted near the figures.

The excellence of the drawings of the Coleoptera has seldom, if ever, been approached and certainly never excelled. Sang was a master in measurement and all the figures are enlarged by a special scale and method devised by Sang himself. The characters are wonderfully shown, punctuation, position and shape of setae, and rugose and even alutaceous surfaces have been faithfully

[1] An admirable obituary notice of John Sang may be found in 1887, *Ent. mon. Mag.* **23** : 278.

reproduced. The mandibles, maxillae, palpi and other mouth-parts are displayed, and separate enlarged drawings of the antennae, their insertion, and very full drawings of the anal appendages are given. Possibly the most beautiful detail is that of the pubescence which in many insects, such as *Emus hirtus*, *Creophilus maxillosus*, is extremely fine.

It was intended to treat the whole of the British Coleoptera in a similar manner, and a commencement was made with the Brachelytra, of which some 1050 drawings were completed, but after some few of the Clavicornia had been finished the great work was ended by the final illness to which the artist succumbed.

Dr. P. B. Mason, by whom Sang was employed in his later years, was an assiduous naturalist and was always referred to as one of the leading entomologists. He was particularly interested in the Coleoptera. He was a great friend of mine and much of my spare time was spent with him whilst in the Midlands. He lived at Bridge House, Burton-on-Trent, where he had constructed a capacious museum out of some cottages adjoining his house, which was contiguous to the banks of the River Trent. In times of flood this presented many difficulties and the insect collections were on this account placed on the first floor. His library was kept chiefly in the adjoining house. He often said that certain of his possessions, including these drawings, which I always so much appreciated, would be well cared for if I possessed them, and at his death they were given to me and have been in my library ever since. The present is an opportunity to say something about Dr. Mason's Coleoptera which is not known to coleopterists today.

Mason's collection of British Coleoptera in Sang's time was regarded as one of the best and perhaps the largest that existed, and he bought either through Mr. Janson, or direct, the entire collections of the following well-known coleopterists: E. C. Rye, E. Brown, A. Hewgill, C. C. Dupre, T. Wilkinson, W. G. Pelerin, J. G. Marsh, G. Wailes, B. Cooke, J. W. Douglas, E. Sheppard (STAPHYLINIDAE), and the Rev. A. Matthews, whose TRICHOPTERYGIDAE were purchased from Mason's executors by the Trustees of the British Museum. He had also a selection of large portions of the collections of Dr. Harper and R. S. Edelsten. E. W. Janson's collection did not go to him but was bought by G. R. Crotch, as was T. V. Wollaston's collection, and these are now in the University Museum, Cambridge, but only a very short series was put in this collection and a great mass of the remainder was placed in Janson's hands by Crotch, and Dr. Mason bought largely from it. In addition his own collection was incorporated.

This comprehensive collection was offered to me by Dr. Mason's trustees and I would have purchased it had the insects been localised and dated, but it was not the fashion in those days to provide such data and the name of the collector was deemed sufficient guarantee that the specimens were really British, which was then all that mattered. The absence of data affected me greatly and I metaphorically visualised every insect provided with an imaginary label printed with the common inscription:

> "At a place which is neither here nor there;
> At a time which is neither now nor then."

and I therefore only purchased the comparatively small collection of J. W. Douglas comprising his British Coleoptera and Hemiptera. The remainder was bought by Bolton (Lancs) Corporation and found a home in the Bolton Municipal Museum. Mr. Midgley, the Curator, informs me that all the specimens drawn by Sang are labelled "Specimen drawn by Sang".

A NOTE ON THE EVOLUTION OF SOME VENATIONAL STRUCTURES IN THE DRAGONFLY WING

By Lt.-Col. F. C. Fraser, I.M.S. Retd., F.R.E.S.

The renaissance this year of our sole British colony of *Oxygastra curtisii* (Dale) has given me the opportunity to further my studies of the venation of the wings of this dragonfly. Variability of this venation, which is so marked a feature of the species, is seen in the rather primitive nodal complex, the presence of accessory veins to the bridge and cubital space, the formation of the discoidal field which may be made up of one or two rows of cells, and lastly and more especially, variation in the shape of the discoidal cell. Such variations are most certainly a reversion to older types and denote a lack of crystallisation of the venation such as has been attained to in the higher types of the family Corduliidae to which *O. curtisii* belongs. On these grounds, this species must be considered as one of the most archaic in the Corduliidae.

As material for my study I have had some 80 wings, and from among them have been able to form a series which demonstrates how the more recent changes in the shape and character of the discoidal cell have come about. As a control to these findings, I have employed the venation of a number of species belonging to *Synthemis* (Corduliidae), *Tetrathemis* (Libellulidae), and *Davidius* (Gomphidae), in which very similar formations occur. Moreover an analysis has been made of the whole of the genera belonging to the Libellulidae and Corduliidae, which serves to show that a cross-vein is present in the discoidal cell of no fewer than 30 genera belonging to the former, and of 8 of the latter, which, however, is a much smaller family. The significance of this cross-vein will be seen presently.

In a long series of wings, and more especially the hind-wings of *O. curtisii*, three main types of the discoidal cell are met with. First and most commonly, is one in which the costal side runs to join MA at an obtuse angle at a point proximal to the cell's distal side. The gap between the costal and distal sides is bridged by a short segment of MA and thus the cell is irregularly four-sided (fig. 1, 1). In this form, the costal side is nearly always bifurcated well proximal to its junction with MA, the posterior branch of the dichotomy running obliquely outwards and backwards to join the distal side of the cell. *It is this branch which persists as a permanent cross-vein to the discoidal cell* in so many genera of the suborder Anisoptera. The point of dichotomy varies from near the proximal to quite near the distal end of the cell, but in *O. curtisii* and often in other species, when the bifurcation nearly reaches the distal side of the cell, the posterior branch becomes obsolete, its function apparently now being in abeyance (fig. 1, 4). In various species of *Davidius*, this process of atrophy may be seen actually taking place and the branch persists merely as short remnants attached to the costal or distal side of the cell, or occasionally to both (fig. 1, 12).

In some cases, the costal side is more or less markedly angulated at the point of bifurcation, thus adding an extra side to the discoidal cell, which now becomes five-sided (fig. 1, 2). This formation is seen at its best in *Pentathemis membranulata* Karsch (fig. 1, 7), but is also quite occasional in species of *Synthemis*

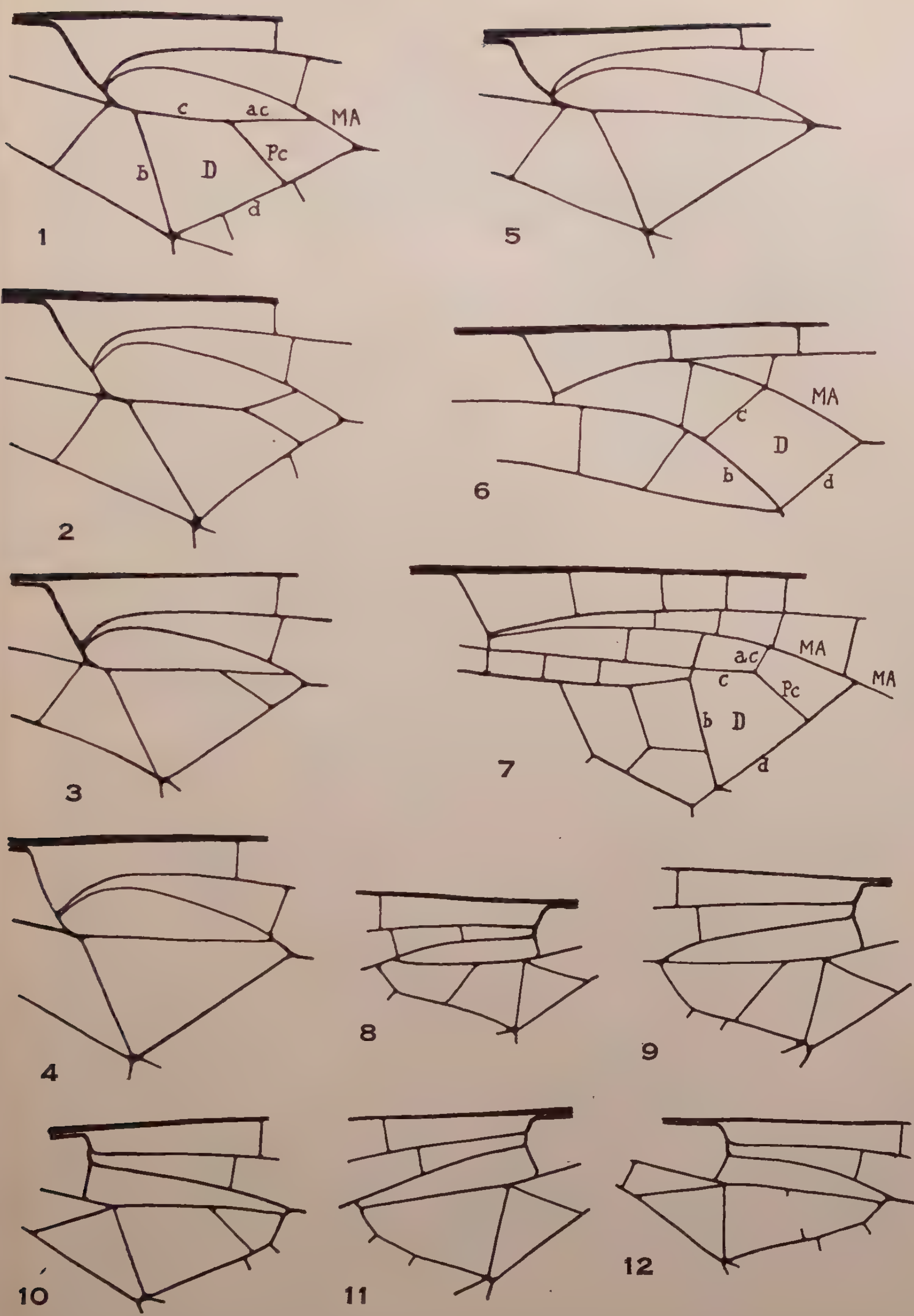


Fig. 1.—1–5. Discoidal cell in *Oxygastra curtisii* (Dale) demonstrating the evolution from an irregular quadrilateral to a regular triangle. 6. Discoidal cell of *Tetrathemis platyptera* Selys. 7. The same of *Pentathemis membranulata* Karsch. 8 to 12. The same of *Davidius cuniculus* Ris. Note in the last figure, the vestigial remains of the posterior branch of the costal side of the cell and that the costal side has processed on to the distal side of the cell. Notation: MA, medianus anticus; D, Discoidal cell; c, b and d, costal, basal and distal sides of discoidal cell; ac and pc, anterior and posterior branches of the costal side of discoidal cell.

and is present in two specimens of my series of *O. curtisii.* Karsch's interpretation of the discoidal cell of *P. membranulata* is therefore proved to be correct after all, and that of Needham and myself wrong: it must be confessed, however, that Karsch made a lucky guess rather than a logical reasoning, for his interpretation was based on the impossibility of the costal side ending up in the discoidal field. It is now known that it can end up in such a position and not infrequently does so (fig. 1, 10–12).

Formerly, authors, including myself, have described the venation of genera such as *Tetrathemis* (fig. 1, 6) as with: "discoidal cell with costal side broken or angulated." From what has been said above, this is now seen to be incorrect, and the correct description should read: "discoidal cell with costal side incompletely processed and with MA forming part of its boundaries." Where the discoidal cell is traversed by a vein running obliquely from the costal to the distal side, the costal side should be described as "dichotomous," which will indicate not only that the cell is crossed by a vein but also the direction and nature of that vein. In the fore-wings of a great number of species of LIBELLULIDAE, the discoidal cell is greatly narrowed in the longitudinal axis of the wing and is traversed by a cross-vein running from the distal to the basal sides. I think it very probable that this represents the same posterior branch of the costal side which has switched from that side to the basal on account of the extreme narrowing of the cell. It should be noted that *it always runs obliquely outwards and backwards* as does the posterior branch of the costal side; if merely a casual cross-vein, then it might be expected to run horizontally.

The second type of discoidal cell represents the culmination of the procession of its costal side along MA, where it finally joins up with the distal side and thus forms a definite triangle. In this type, the costal side may be simple or dichotomous, that is, the cell may be entire or traversed by an oblique vein between its costal and distal sides. The third type is quite the rarest and is produced by one of two methods: either by the costal side processing still further and passing from MA on to the distal side, or by the posterior branch of the costal side persisting at the expense of the anterior branch, which becomes obsolete. I do not believe that this latter method is commonly if at all employed, otherwise an angulation of the costal side might be expected to occur in this type; such, however, is unknown (fig. 1, 11).

In my series of wings, these three types are closely linked up by a chain of transitional forms, so closely graduated into one another that they might well be the successive shots of a cinematograph film, and leave no doubt as to the steps evolution has taken (fig. 1, 1–5). Further study will be necessary to determine why the posterior branch of the costal side of the discoidal cell persists in some genera and becomes atrophic in others, but since all parts of the wing's venation are mechanically dependent on the others, the generic differences in venation may well have influenced changes in one or the other direction.

THE "NODAL BRACE."

In exactly half of the genera belonging to the family LIBELLULIDAE (excluding the CORDULIINAE, which are now regarded by most authors as a separate family) the distal antenodal vein is incomplete in the fore-wings, that is, it is present in the costal space only. In its typical form, it is present as a very oblique vein sloping up from the subcosta outwards to join the costa at a point a little proximal to the nodus. Because of its proximity to the latter and

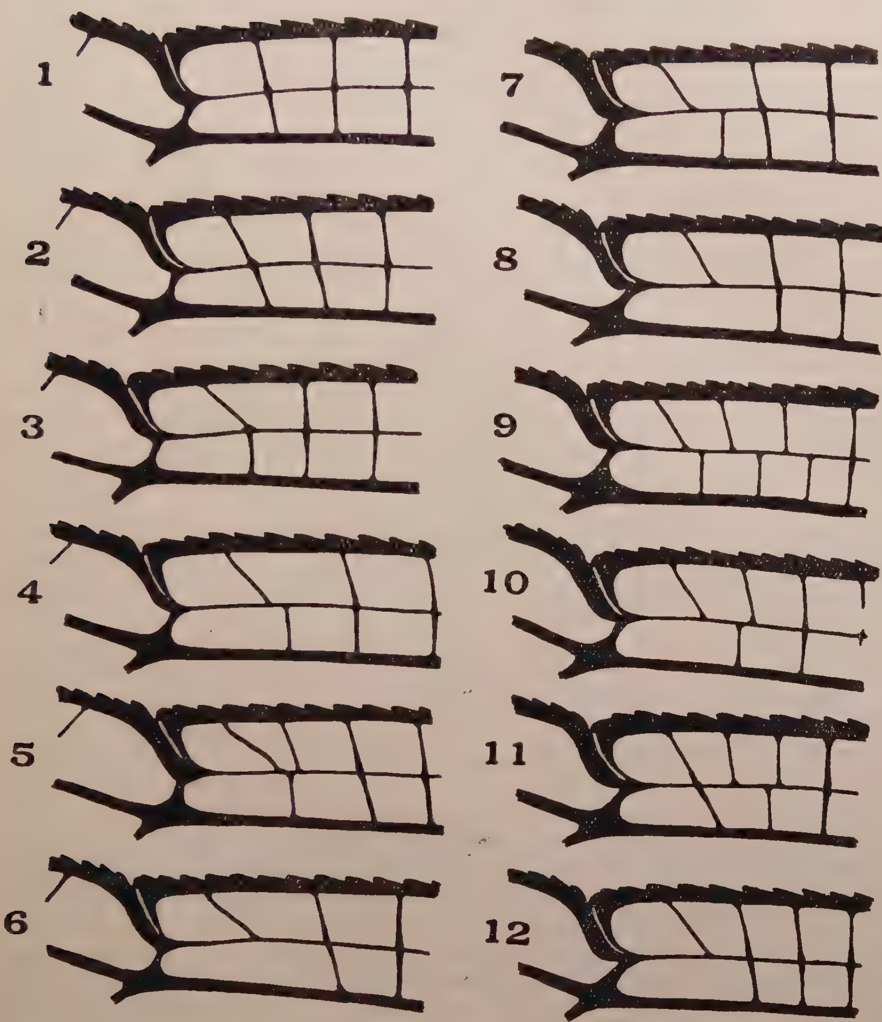


FIG. 2.—The Nodal Brace : 1. Fore-wing of *Tetrathemis platyptera* Selys, showing the distal antenodal vertical. 2. The same of *Libellula quadrimaculata* L., distal antenodal now markedly oblique. 3. Right fore-wing of *Libellula depressa* L., costal half of distal antenodal now more oblique than the subcostal half. 4. Left fore-wing of same specimen as last. Subcostal half of distal antenodal has recessed. 5. Fore-wing of *Libellula quadrimaculata* L. Here a supplementary antenodal appears, to complete the recessed half of the subcostal antenodal. 6. Fore-wing of same species as last, showing the subcostal distal antenodal obsolete and leaving the costal half isolated as the normal and recent " Nodal brace." 7. Right fore-wing of *Zygonyx torrida* (Kirby). 8. Left fore-wing of same specimen. 9. Fore-wing of *Libellula quadrimaculata* L. 10. Hind-wing of same specimen as last showing presence of incomplete antenodal. 11. *Libellula saturata* Uhler. Here an accessory antenodal appears in the costal space preparatory to the recession of the subcostal half of the distal antenodal. 12. *Libellula auripennis* Burmeister showing the condition which occurs in both fore- and hind-wings in this species.

of its analogy to the brace to the stigma, I have named it the "Nodal Brace." Of the remaining genera of the LIBELLULIDAE, it is present in a transitional form in 59 and absent altogether in 21. In the genus *Cyanothemis* Ris, it is present in the hind-wings as well as in the fore-wings, and because of this, its author considered it one of the most remarkable genera known and that it was unique in this respect. He could not, however, have bestowed his customary care upon this matter, for I find that it is commonly present in the hind-wings of several species of the genera *Libellula* and *Onychothemis*, whilst it crops up very occasionally in other genera. I find it present in 100% of the hind-wings of *Libellula auripennis* in my own collection, and it is shown so in the figure of the wings given by Ris in his monograph on the LIBELLULINAE. It is also present in 50% of the specimens of *Libellula incesta* and *cyanea*, and may be present actually in the hind-wings of these species when it is absent in the fore-wing!

Professor Needham, in his valuable work :—" A Genealogic Study of Dragonfly Venation," has overlooked this feature of the Libelluline wing and no subsequent writer has dealt with the subject. Ris employed it freely as a generic character in his classification of the LIBELLULINAE and, although he made no comment as to its significance, I think, must have regarded it as of some phylogenetic importance. The present paper offers a suggestion as to its function and shows how it has evolved from the complete distal antenodal vein by an atrophy of the subcostal half.

At the outset of the study, two striking facts were noticed : first, the complete absence of such a vein in the CORDULIIDAE (from which the LIBELLULIDAE arose), and secondly, the absence of the vein in the most archaic genera belonging to the latter family. Clearly, then, the incomplete antenodal was of recent formation, and a study of the wings of all known forms ought to demonstrate intermediate stages in the evolution of the vein. Such stages have been found and not only in the different genera but in the wings of individual species in which the venation has not yet become fully crystallised. Four stages of evolution exist, but, in some cases, minor variations of these may be found. The first of these is exemplified by the most archaic forms of the LIBELLULIDAE such as *Tetrathemis* and *Palaeothemis*, in which the distal antenodal is quite perpendicular to the radius and subcosta and is always complete (fig. 1). The second stage is marked by an obliquity of the distal antenodal which is still complete and with the costal and subcostal portions in strict alignment : some obliquity of the penultimate distal antenodal is usually present at the same time (fig. 2). At such a stage, any strain from the costa will be transmitted direct to the radius. In the third stage, the obliquity of the costal portion of the distal antenodal increases at a greater pace than that of the subcostal portion so that the two are now no longer in alignment; the vein is still complete but angulated, so that any strain from the costa is transmitted partly to the subcosta and partly to the radius (fig. 3). With increasing obliquity of the costal portion of the antenodal, this strain will become more and more reflected on to the subcosta, until a point arises where it passes entirely to this structure. From that moment, the subcostal portion of the distal antenodal vein becomes redundant and, like all such structures, atrophies and disappears. This brings the evolution to the last or fourth stage (figs. 6, 8, 10 and 12). A modification is commonly found, in which the subcostal portion of the distal antenodal instead of becoming atrophied, recesses towards the base of the wing and thus leaves the costal portion isolated as a brace to the nodus : at the same time, a costal antenodal is added to complete the recessed incomplete subcostal portion (figs. 4, 5, 7, 9 and 10). The orderly balance of the antenodal complex may be upset, so that its

distal portion may exhibit a more or less marked lack of alignment of the costal and subcostal antenodals (figs. 9 and 11). A prolonged study of the comparative anatomy of these parts and the shape of the wings has not enabled me so far to discover why the nodal brace should be evolved in some genera and not in others. In many cases, conditions seem to be identical so that I am compelled to think that the character of the flight may play a large part in the evolution of the nodal brace, this obviously being a response to an increased load on the costal postnodal portion of the wing. Its presence in the fore-wings only, of the great majority of the species, is certainly due to the fact that the fore-wings act chiefly as propellers whilst the hind-wings function chiefly as planes in the Anisoptera: thus a greater strain is thrown on the postnodal and apical portions of the fore-wing than on the same parts of the hind-wing. Here, again, the presence of an incomplete antenodal in the hind-wing as well as the fore-wing in *Cyanothemis* and *Libellula* may be due to some peculiarity in the character of their flight.

The character of the nodal brace or distal antenodal becomes now of considerable importance phylogenetically, since a complete and perpendicular one denotes an archaic species; an oblique but complete one, a little less archaic; an oblique, complete but angulated one inclining to the recent forms, whilst an incomplete antenodal or fully evolved nodal brace is recent in origin. It is of interest that this has been largely confirmed by the Risian classification of the Libellulidae.

Ris, in his classification of the Libellulidae, has placed right at the very end of the family a small group of four genera, *Urothemis*, *Macrodiplax*, *Aethriamanta* and *Selysiothemis*. In all of these the distal antenodal of the fore-wings is complete and but slightly oblique, that is, it is almost exactly similar to what is found in the most archaic genera of the family. This "meeting of extremes" is very difficult to explain and is quite contrary to what ought to be expected in the most recent forms of the family. This being so, it tends to throw a strong element of doubt on the correctness of the placing of the group and in support of this, is the presence ~~in all~~ of a peculiar protuberance on the outer side of the eyes, a feature which is quite unknown in any other Libelluline genus, but which is present in an exaggerated form throughout the Corduliidae. Comparing the venation of this group with a typical Corduline such as *Tetragoneuria* a remarkable resemblance is found: the separation of the sectors of the arculus from their very origin, the area of the discoidal cell and the formation of the antenodal complex are entirely similar, as are other features. Thus it is possible that a closer relationship exists between this group and the Corduliidae than in the rest of the Libellulidae, and that the group has arisen from another stem.

PUBLICATIONS

The Publications of the Royal Entomological Society are *Transactions* and *Proceedings*.

The *Transactions* form an annual volume, each paper in the volume being issued as a separate part. The parts are issued irregularly throughout the year.

The *Proceedings* are issued in three series:

Series A. General Entomology

Series B. Taxonomy

Series C. Journal of Meetings

Series A and B are issued in twelve parts, forming an annual volume of approximately 240 pages.

The following information is supplied for the guidance of authors wishing to submit papers for publication in any of the Society's journals.

INTRODUCTORY

The Society is prepared to undertake the provision of a reasonable number of text figures. The original drawings for such figures must be supplied by authors. Such drawings or groups of drawings must be drawn to a scale which will permit of their reduction to an area of dimensions not exceeding $7\frac{3}{4} \times 4\frac{3}{4}''$. In the case of the *Proceedings Series A* and *Series B*, authors are required to pay for the necessary blocks for the provision of plates, half-tone and coloured work.

A uniform method is adopted for the citation of bibliographical references in the Society's publications as follows:

Smith, A., 1936, New species of Coccidae, *Proc. R. ent. Soc. Lond.* (B) **6** : 301–306, pl. 1.

——. 1936, New species of Coccidae, *Trans. R. ent. Soc. Lond.* **84** : 901–936.

Titles of periodicals cited are to be abbreviated in the manner indicated in the *World List of Scientific Periodicals, 2nd edition*, 1934.

Authors are entitled to receive 25 copies of their papers free of charge and may purchase additional copies provided that request be made before publication.

Papers offered for publication should be sent to the Secretary, Royal Entomological Society of London, at *41, Queen's Gate, London, S.W.7*, and must be typewritten on one side of the paper only. Sufficient space must also be left between the lines for editorial corrections.

TRANSACTIONS

Papers offered for publication in the *Transactions* are considered by the Publication Committee of the Society, which meets usually in the months of May and November. In order that papers may be considered at these meetings it is necessary for the manuscript and drawings for any illustrations to be in the hands of the Secretary fourteen days before the meeting of the Committee.

Papers of less than eight printed pages (approximately 7000 words) will not normally be accepted for the *Transactions*, and papers by authors who are not Fellows of the Society must be communicated by a Fellow.

PROCEEDINGS SERIES A AND SERIES B

Papers submitted for publication in either *Series A* or *Series B* of the *Proceedings* by authors who are not Fellows of the Society may be accepted if they are communicated by a Fellow. Preference will be given to papers written in the English language, and papers of more than eight printed pages (7000 words) will not normally be accepted for publication in these journals.

PROCEEDINGS SERIES C

Series C is issued prior to every General Meeting. It contains abstracts of exhibits to be shown and communications to be made, together with the titles of papers accepted for publication.

The annual subscription to *Series A. General Entomology* is *£2 0s. 0d.; Series B. Taxonomy, £2 0s. 0d.* (single parts *4s. 0d.*); and *Series C. Journals of Meetings, 6s. 0d.*

As from January 1936 the journal *Stylops* is continued as *Proceedings Series B. Taxonomy.* Copies of volumes 1–4 are available at *£1 16s. 0d.* each, post free.

MEETINGS
TO BE HELD IN THE SOCIETY'S ROOMS
41, Queen's Gate, S.W.7

1942.

WEDNESDAY,	October	7
,,	November	4
,,	December	2

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

The Fellowship and Fees

Fellows pay an Admission Fee of £3 3*s*. The Annual Contribution of £2 2*s*. is due on the first day of January in each year, and is payable in advance. Fellows under the age of 25 years may pay the entrance fee in three equal annual instalments.

Fees should be paid to the Treasurer, at 41, Queen's Gate, S.W.7, and *not to the Secretary*.

Fellows desiring to pay their Annual Contribution through their bankers may obtain an official form of banker's order by applying to the Treasurer.

Fellows whose Contributions for the current year have been paid are entitled to receive the *Transactions* and *Proceedings* of the Society free of charge. Further copies may be purchased at reduced prices by applying to the Registrar.

Forms of application for Fellowship, copies of the Bye-Laws and the List of Fellows may be obtained from the Registrar.

Meetings and Exhibitions

Fellows and others wishing to make a communication to a General Meeting of the Society are requested to send in their names, the title of their exhibit, and a short abstract of their remarks, to the Registrar fourteen days before the meeting at which it is proposed to make the communication. Should it be desirable to publish a fuller account of the communication the manuscript may be submitted for publication in *Proceedings Series A* or *Series B*. If the epidiascope is required, 24 hours' notice must be given. Objects for projection should not exceed 6 ins. by 6 ins.

Fellows resident abroad, or otherwise unable to attend meetings, are reminded that notes or observations sent to the Secretary may be communicated to a General Meeting on their behalf.

PRINTED FOR THE SOCIETY BY RICHARD CLAY AND COMPANY, LTD.,
BUNGAY, SUFFOLK.